GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 20, 1846.

REPORT OF THE COUNCIL.

E Council have the satisfaction of again calling the attention of Members of the Geological Society to the prosperous state of its affairs, as shown by the increasing number of its Fellows. At the close of 1844 the numbers had been reduced by unusual mortality from 883 to 875; in the course of the past year the number of new admissions has greatly exceeded that of deaths and resignations. During that period 27 new Fellows have been elected, and 5 who had been elected in the preceding year have paid their entrance fees, making a total increase of 32. On the other hand, there have been 13 deaths, 4 resignations and 2 defaulters removed, leaving an increase of ordinary Fellows of 13. They have at the same time to announce the death of 2 Foreign Members and of 3 Honorary Members, and the election of 1 Foreign Member, thus causing a further reduction of 4, and reducing the total increase to 9.

This number however must be further diminished by 1 in consequence of the name of a distinguished transatlantic geologist being inserted twice; Prof. H. D. Rogers having been elected a Foreign Member when his name was already on the list as a non-resident Fellow. Thus at the close of 1845 the real increase of the Society was 8, and the total number of Fellows was again raised to 883 from 875.

The Council have further the satisfaction of stating that the excess of income over expenditure during the year 1845 amounted to the sum of 40*l.* 16*s.*

At the close of 1845 the number of living compounders was 123, and the amount received from them in lieu of annual contributions was 3874*l.* 10*s.* During the past year 8 newly-elected Fellows have compounded, 7 of whose compositions have been already invested, in accordance with the now-established practice of the Society, and added to its funded property, which thus received an increase of 220*l.* 10*s.*; but in consequence of the great fall in the price of Consols, from *par* (at the close of 1844) to 94 (at the close of last year), the estimated value of the funded property was only increased from 2896*l.* 11*s.* 3*d.* (the amount stated last year) to 2961*l.* 5*s.* 6*d.*

In consequence of Mr. Woodward, the Sub-Curator of the Museum, having received the appointment of Professor of Natural History at the Agricultural College of Cirencester, he resigned his

office in this Society during the course of last year. The Council, in considering the arrangements to be made in filling up Mr. Woodward's place, and the necessity of obtaining the services of an efficient officer, resolved that a different distribution of the duties of the Vice-Secretary was desirable.

At the same time other changes were required in the manner in which the Journal was to be conducted, in consequence of which the Council resolved that the Vice-Secretary should be relieved from all superintendence of the Library and Museum, and that his duties at the Society should be confined, at a reduced salary, to the care of all papers communicated to the Society, and to editing the Transactions and Journal.

The Council have the satisfaction of stating that they have secured the services of Mr. J. De C. Sowerby as Curator and Librarian. Mr. Sowerby's attainments and skill in fossil conchology are too well known to require any remarks on this occasion; the appointment was subsequently confirmed by the General Meeting, to whom, in conformity with the bye-laws, it was submitted; and the Council look forward to seeing the Museum and Collections shortly rendered, through his labours, more available to the Fellows of the Society.

It was stated in the Annual Report of last year that an agreement had been made with Messrs. Longman and Co. for the regular publication of the Quarterly Journal of the Geological Society. This agreement was made for one year, renewable at the expiration of that period. At the end of the year however Messrs. Longman and Co. gave notice that they declined to continue the arrangement any longer, or to run any further risk. The Council, after full consideration, and being satisfied that under existing circumstances the Journal is the most advantageous form in which a large proportion of the papers read at the meetings can be published, determined to continue it on the Society's account for the ensuing year, the Vice-Secretary remaining the editor, under the superintendence of the President and Secretaries. A letter has been addressed by the Secretary to the Fellows, stating all particulars respecting the Journal, and also explaining the reasons why they have considered it expedient for the future, or at least during such period as the present form of an illustrated Journal shall be kept up, to discontinue the gratuitous distribution of these illustrated Proceedings to the Fellows, and not to publish them otherwise than in the Journal.

During the last year the seventh volume of the Transactions has been commenced, and that form of publication will be continued for those papers requiring illustration which cannot be adequately given in an octavo form. The Council have been induced to try the plan adopted by some Foreign Societies, of publishing the papers separately, each memoir constituting a part, which when there is a sufficient number will form a volume, and for which a title-page and index will be printed. The funds disposable for this purpose did not allow of more than one part being published at the Society's expense; but Mr. Warburton and Mr. Greenough, feeling the importance of an early publication of the discovery by Mr. Bain, with

Professor Owen's description, of fossil remains of bidental and other reptiles in South Africa, hitherto unknown, an opinion in which the Council entirely concurred, liberally supplied the funds for the publication of these communications.

The Council have further the satisfaction of stating that they have received information through the Earl of Lincoln, that the Government have awarded the sum of £200 to Mr. Geddes Bain, in consideration of the exertions he has made towards bringing to light the fossil remains of Southern Africa.

In conclusion, they have to announce that they have awarded the Wollaston Palladium Medal and the balance of the proceeds of the Donation Fund for the present year, amounting to £30 1*s.* 6*d.*, to William Lonsdale, Esq., F.G.S., for his many valuable contributions to Geological science, and more especially for his description of the Corals in the Silurian and Devonian rocks, for his late Report in the first volume of the Quarterly Journal of the Geological Society on the Corals from the Tertiary formations of North America, and for his description of the Corals from the Palæozoic formations of Russia.

Report of the Museum and Library Committee.

The Museum continues in nearly the same state as when the Report was made last year. In consequence of Mr. Woodward's engagements with the Journal and subsequent absence, no progress has been made in carrying out the former resolutions of the Council respecting it. Few specimens have been added during the last year: they consist of—

Tertiary.—Bones from the Eocene strata of Hordwell and Barton, presented by Thomas Falconer, Esq.

Specimens of Foraminifera from Charing, by W. Harris, Esq.

Chalk.—Chalk Fossils from Trimmingham, by Miss Gurney.

Spongeous Flint, by Mr. H. Ball.

Beryx radians, Maidstone, by E. H. Bunbury, Esq.

Kentish Rag,—Fossils from Maidstone, Mr. W. H. Bensted.

Wealden.—Unio Valdensis, Isle of Wight, Dr. Mantell.

Slab of Paludina, Weald, W. Harris, Esq.

Great Oolite.—Specimens from Kate's Cabin, Peterborough, by H. M. Lee, Esq.

Lias.—Part of the head of an Ichthyosaurus, of which the other portion is in the Society's collection; presented by the Earl of Enniskillen, Sir P. Egerton, Mr. Stokes, Mr. Murchison, Mr. Warburton, and Mr. Broderip.

Coal.—Calamites pachyderma, &c. from Oldham, by E. A. Wright, Esq.

Series of specimens of Shells, &c. from Coalbrook Dale, by W. Anstice, Esq.

Mountain Limestone.—Palates, Teeth, and Spines of Fish, from the limestone of Armagh, by Capt. Jones, R.N.

Specimen of Orthoceratite, Ireland, from W. Thompson, Esq.

Devonian System.—Polished Corals, Devonshire, presented by the Marquis of Northampton.

Pebbles from Schabar, by G. A. Mantell, LL.D.

Pholas clavata on Teak timber, by Capt. J. W. Symonds, R.N.

Foreign Specimens.

Fossils from the Azores, by C. Hunt, Esq.

Three Terebratulæ, by Baron Von Buch.

Specimens of Palæozoic Fossils from New South Wales, by the Rev. H. S. Clark.

Specimen of Gypsum, by Charles Stokes, Esq.

The Committee have ascertained that a resolution adopted last year by the Council, to the effect "that all specimens belonging to the Society, in the hands of Fellows, be immediately returned," has been only partially carried into effect.

Library.

The Vice-Secretary has been engaged in preparing a Catalogue of the Books and Maps, the first sheets of which are already printed, and the whole will be shortly completed. Donations of about 180 volumes and pamphlets have been received during the past year.

S. P. PRATT.
H. FALCONER, M.D.
ROBERT AUSTEN.

Comparative Statement of the Number of the Society at the close of the years 1844 *and* 1845.

	Dec. 31, 1844.		Dec. 31, 1845.	
Compounders		116		123
Residents		230		250
Non-residents		452		437
		798		810
Honorary Members	23		20	
Foreign Members	50		49	
Personages of Royal Blood	4	—77	4	—73
		875		883

General Statement Explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1844 *and* 1845.

Number of Fellows, Compounders, Contributors, and Non-residents, December 31, 1844			798
Add, Fellows elected during former years, and paid in 1845	Residents 3 Non-residents 2	5	
Fellows elected during 1845, and who paid	Residents 17 Non-residents 10	27	
			32
			830
Deduct, Compounder deceased		1	
Residents ,,		3	
Non-residents ,,		9	
Resigned		4	
Removed		2	
Non-resident, being also on the Foreign List		1	
			20
Total number of Fellows, 31st Dec. 1845, as above			810

Number of Honorary Members, Foreign Members, and Personages of Royal Blood, December 31, 1844		77
Add, Foreign Member elected		1
		78
Deduct, Honorary Members deceased	3	
Foreign Members ,,	2	
		5
Total as above		73

Number of Fellows liable to Annual Contribution at the close of 1845, *with the Alterations during the year.*

Number at the close of 1844		230
Add, Elected in former years and paid in 1845		3
Elected during 1845 and paid		17
Non-residents who became Residents		18
		268
Deduct, Deceased	3	
Resigned	3	
Compounded	8	
Removed	2	
Became Non-resident	2	
		18
Total as above		250

Deceased Fellows.

Compounders (1).

Edward Wood, Esq.

Residents (3).

John Backhouse, Esq.
R. C. Sale, Esq.
William Taylor, Esq.

Non-Residents (9).

R. T. Atkinson, Esq.
T. J. L. Baker, Esq.
Col. Edward Clive.
Sir C. H. Colville.
J. S. Duncan, Esq.
Hugh Edwards, Esq.
S. L. Kent, Esq.
Thomas Meade, Esq.
Lieut.-Col. M. Shaw.

Honorary Members (3).

Dr. J. MacDonnell.
J. A. MacKonochie, Esq.
James Oakes, Esq.

Foreign Members (2).

Cavaliere Monticelli.
Count Münster.

The following Persons were elected Fellows during the year 1845.

January 8th.—George Dawson, Esq., Birmingham.

January 22nd.—David Walker, Esq., M.A., Colchester.

February 5th.—Thomas Longman, Esq., 2 Hanover Terrace, Regent's Park; John Durancé George, Esq., 32 Old Burlington Street; and Capt. Barham Livius, Dover.

February 26th.—John Fowler, Esq., Stockton upon Tees.

March 12th.—Sir Robert Burdett, Bart., Ramsbury Park, Wilts; and Warrington W. Smyth, Esq., 3 Cheyne Walk, Chelsea.

April 2nd.—Waller Augustus Lewis, Esq., B.A., 18 Stratford Place; Capt. Washington, R.N., F.R.S.; Albemarle Bettington, Esq., 23 Hanover Square; Robert Stephenson, Esq., 15 Cambridge Square; George Stephenson, Esq., Tapton House, near Chesterfield; Lieut. Baird Smith, of the Engineers, Bengal Army; Capt. Thomas Hutton, of the Bengal Army; John MacClelland, Esq., of the Bengal Medical Service; and the Earl of Auckland, Eden Lodge, Kensington.

May 14th.—John Collis Nesbit, Esq., 38 Kennington Lane; Thomas Graham, Esq., M.A., Professor of Chemistry, University College, London; and Joseph Yelloly Watson, Esq., Malvern Cottage, St. Ann's Road, Brixton.

May 28th.—Captain Thomas E. Bigge, 19 Bryanstone Square; Matthew Bell, Esq., Bourne Court, Kent, and 4 Grosvenor Crescent; and John Alexander Hankey, Esq., 36 Brook Street.

June 11th.—Alexander Keith Johnston, Esq., Edinburgh; Brooke Cunliffe, jun., Esq., Erbistoch Hall, North Wales; The Earl of Lincoln, Chief Commissioner of Her Majesty's Woods and Forests; and Edward Solly, Esq., 38 Bedford Row.

December 3rd.—James Ashwell, Esq., B.A., St. Peter's College, Cambridge; and A. W. Jackson, Esq., Hoddesdon.

December 17.—John Morris, Esq., High Street, Kensington; and Dr. Edward Kelaart, of the Army Medical Staff.

The following Person was elected a Foreign Member.

March 12th.—M. Alcide d'Orbigny, Vice-President of the Geological Society of France.

The following Donations to the Museum have been received since the last Anniversary.

British and Irish Specimens.

Specimens of the *Unio Valdensis* from the Wealden of the Isle of Wight; presented by G. A. Mantell, LL.D., F.G.S.

Slab of *Paludinæ* from the Weald at Pluckley, and Corals, Shells and Foraminifera from the Chalk of Charing, Kent; presented by Wm. Harris, Esq., F.G.S.

Fossils from the Great Oolite, Kate's Cabin in Peterborough; presented by H. M. Lee, Esq., F.G.S.

Gigantic Head of *Ichthyosaurus*, the remaining portion of a specimen already in the possession of the Society; presented by H. Warburton, Esq., M.P., the Earl of Enniskillen, R. I. Murchison, Esq., Sir Philip Egerton, Bart., M.P., Charles Stokes, Esq., and W. J. Broderip, Esq., F.G.S.

Series of Specimens from Coalbrook Dale; presented by W. Anstice, Esq., F.G.S.

Palates, Teeth and Spines of Fish from the Carboniferous Limestone of Armagh; presented by Capt. Jones, R.N., F.G.S.

Specimen of *Orthoceratite* from the Mountain Limestone of Ireland; presented by W. Thompson, Esq., F.G.S.

Polished sections of Corals from South Devon; presented by the Marquis of Northampton, F.G.S.

Specimen of Gypsum; presented by Charles Stokes, Esq., F.G.S.

Specimen of the *Pholas clavata* in Teak Timber; presented by Capt. Sir W. Symonds, R.N.

Calamites pachyderma and other Coal-plants from Glodwick Colliery, Oldham; presented by E. A. Wright, Esq.

London Clay from the bed of the Thames opposite Limehouse; presented by George Rennie, Esq.

Foreign Specimens.

Three species of *Terebratula*; presented by Baron Leopold Von Buch, For. Mem. G.S.
Specimens of Rocks and Palæozoic Fossils from New South Wales; presented by the Rev. W. B. Clarke, F.G.S.
Pebbles from Ichaboe; presented by G. A. Mantell, LL.D., F.G.S.

Charts and Maps.

Ordnance Townland Survey of the County of Cork, in 155 sheets; presented by Col. Colby, R.E., by direction of the Lord Lieutenant of Ireland.
The Charts published by the Admiralty during the year 1844; presented by Capt. Beaufort, R.N., by direction of the Lords Commissioners of the Admiralty.
Sheets 19 to 33, and 35 to 43 inclusive of the Geological Survey of Great Britain; presented by Sir H. T. De la Beche, For. S. G.S., by direction of the Chief Commissioner of Her Majesty's Woods and Forests.
Essai d'une Carte Géologique du Globe Terrestre, par M. A. Boué; presented by the Author.
Map of the Coal district eastward of Glasgow; presented by L. Horner, Esq., P.G.S.
Carte Géologique du Terrain entre le lac d'Orta et celui de Lugano, par M. Leopold de Buch; presented by the Author.
Croquis provisional de una Parte del Terreno Carbonifero de Asturias con la Indicacion de los, &c.; presented by the Asturian Mining Company.
Map of the Cape of Good Hope; presented by H. Warburton, Esq., F.G.S.

Lithographic Drawing of a Fossil Jaw; presented by W. K. Bridgeman, Esq.
Lithographic Drawing of a gigantic Ruminant; presented by Mr. Bettington.
Lithographic Drawing of an imprinted Slab from the New Red Sandstone at Weston, Cheshire; presented by Dr. James Black, F.G.S.
Portrait of the late Francis Baily, Esq., P. Ast. Soc.; presented by the Rev. Richard Sheepshanks, F.G.S.

Medallion of Mr. J. De Carle Sowerby; presented by Mr. J. De Carle Sowerby.

The following List contains the Names of all the Persons and Public Bodies from whom Donations to the Library and Museum were received during the past year.

Academy of Sciences of Paris.
Admiralty, The Right Hon. the Lords Commissioners of the.
Agassiz, Prof. L., For. Mem. G.S.
American Philosophical Society held at Philadelphia.
Ansted, Prof. D. T., F.G.S.
Anstice, W., Esq., F.G.S.
Asturian Mining Company.
Athenæum, Editor of the.

Benett, Miss.
Bettington, A., Esq., F.G.S.
Black, James, M.D., F.G.S.
Boston Society of Natural History.
Boué, Mons. A.
Braim, T. H., Esq.
Brayley, E. W., Esq., F.G.S.
Bridgeman, W. K., Esq.
British Association for the Advancement of Science.
Broderip, W. J., Esq., F.G.S.
Brodie, Rev. P. B., F.G.S.
Buckman, James, Esq., F.G.S.
Bunbury, E. H., Esq., F.G.S.

Cangiano, L., Esq.
Catullo, Prof. T. A.
Chemical Society of London.
Clarke, Rev. W. B., F.G.S.

Dana, J. D., Esq.
D'Aoust, M. V.
Daubeny, Prof., M.D., F.G.S.
De la Beche, Sir H. T., F.G.S.
Dépôt Générale de la Marine de France.
De Walterhausen, M.
Dufrésnoy, M., For. Mem. G.S.
Durocher, M. J.

Egerton, Sir. P., Bart., M.P., F.G.S.
Élie de Beaumont, M., For. Mem. G.S.
Enniskillen, Earl of, F.G.S.

Falconer, H., M.D., F.G.S.
Fox, R. W., Esq.
Franklin, Sir J., K.C.H., F.G.S.

Geological Society of Dublin.
Geological Society of France.
Gervais, M. P.
Gibbes, R. W., M.D.
Gregory, W., M.D.

Haarlem Société Hollandaise des Sciences.
Hall, James, Esq., F.G.S.
Harris, W., Esq., F.G.S.
Hausmann, Prof. J. F. L., For. Mem. G.S.
Helmerson, Herr G. von.
Horner, L., Esq., Pres. G.S.

Jackson, C. T., M.D.
Jones, Capt., R.N., M.P., F.G.S.

Kerigan, T., Esq.
King, W., Esq.

Lee, H. M., Esq.
Lyell, C., Esq., F.G.S.

Macaire, Prof.
Mackintosh, A. F., Esq., F.G.S.
Mantell, G. A., LL.D., F.G.S.
Michelin, H., Esq.
Modena Society.
Müller, Herr Joh.
Murchison, Sir R. I., F.G.S.
Museum of Natural History of Paris.

New York Dissector, Editor of.
Northampton, Marquis of.
Northumberland Natural History Society.
Nicol, James, Esq.
Nyst, M. P. H.

Ordnance, Master-General and Board of.

Philadelphia Academy of Natural Science.
Pictet, M. F. J.
Pilla, Herr L.

Quetelet, M. A.

Redfield, W. C., Esq.
Reeve, Mr. Lovell.
Rennie, G., Esq., F.G.S.
Royal Academy of Berlin.
Royal Academy of Brussels.
Royal Academy of Munich.
Royal Agricultural Society of England.
Royal Asiatic Society.
Royal Geographical Society.
Royal Irish Academy.
Royal Polytechnic Society of Cornwall.
Royal Society of Edinburgh.
Royal Society of London.

Sabine, Lieut.-Colonel, F.G.S.
Scacchi, Signor A.
Sheepshanks, Rev. R., F.G.S.
Silliman, Prof., M.D., For. Mem. G.S.
Simms, F. W., Esq., F.G.S.
Society of Arts.
Stockholm Academy.
Stokes, Charles, Esq., F.G.S.
Symonds, Capt. Sir W., R.N.

Taylor, Richard, Esq., F.G.S.
Taylor, R. C., Esq., F.G.S.
Tchihatcheff, M. P. de.
Thibert, F., M.D.
Thompson, W., Esq., F.G.S.

Von Buch, Baron, For. Mem. G.S.

Warburton, H., Esq., M.P., F.G.S.
Washington National Institution.
Wright, C. A., Esq.

Zoological Society.

List of PAPERS *read since the last Annual Meeting, February* 21*st*, 1845.

Feb. 26th.—On the Miocene Tertiary Strata of Maryland, Virginia, and North and South Carolina, by Charles Lyell, Esq., F.G.S.

———————— On the White Limestone and Eocene Formations of Georgia and South Carolina, by Charles Lyell, Esq., F.G.S.

March 12th and Jan. 7th, 1846.—On the Comparative Classification of the Fossiliferous Slates of North Wales, Westmoreland and Lancashire, by the Rev. Adam Sedgwick, M.A., F.G.S., Woodwardian Professor in the University of Cambridge.

April 2nd.—On an Aërolite said to have fallen near Lymington, Hants, by R. A. C. Austen, Esq., F.G.S.

———————— On the Junction of the Transition and Primary Rocks of Canada and Labrador, by Capt. Bayfield, R.N.

April 16th.—On the supposed evidences of the former existence of Glaciers in North Wales, by Angus Friend Mackintosh, Esq., F.G.S.

April 30th.—On the Palæozoic Deposits of Scandinavia and the Baltic Provinces of Russia, by Sir R. I. Murchison, V.P.G.S.

May 14th.—Extract of a Letter from Dr. A. Gesner, on the Gypsiferous Red Sandstone of Nova Scotia.

May 14th.—On the Coal Beds of Lower Normandy, by R. A. C. Austen, Esq., F.G.S.

———— Notes of a Microscopical Examination of the Chalk and Flint of the South-East of England, by G. A. Mantell, LL.D., F.G.S.

———— On some Specimens of Pterodactyle, recently found in the Lower Chalk of Kent, by J. S. Bowerbank, Esq., F.G.S.

May 28th.—On the Geology of Lycia, by Edward Forbes, Esq., F.G.S., Professor of Botany in King's College, London, and Lieut. Spratt, R.N., F.G.S.

———— On a new Family of Crinoidal Animals called *Cystideæ*, by Baron Leopold von Buch, For. Mem. G.S.

———— On the relation of the New Red Sandstone to the Carboniferous strata in Lancashire and Cheshire, by E. W. Binney, Esq.

June 4th.—On Dust falling on Vessels in the Atlantic Ocean, by Charles Darwin, Esq., F.G.S.

———— On Foraminifera in the Lias, by H. E. Strickland, Esq., F.G.S.

———— On Spirifers from the Lias, by James Buckman, Esq., F.G.S.

———— On Artificial Graphite, by William Brockedon, Esq.

———— On the Piræus at Athens, by the Rev. Robert Everest, F.G.S.

———— On an Elephant's Tusk found in the Gravel of Kent, by — Charlton, Esq.

———— On the Ear-bone of a Whale found in the Crag near Ipswich, by C. B. Rose, Esq., F.G.S.

———— On Scotch Boulders, by James Smith, Esq., F.G.S.

November 5th.—On Footsteps on a Slab of New Red Sandstone, by James Black, M.D., F.G.S.

———— On the Granite of Lundy Island, by the Rev. David Williams, F.G.S.

———— On the Geology of the neighbourhood of Tremadoc, by J. E. Davis, Esq., F.G.S.

November 19th.—On the Age of the newest Lava Current of Auvergne, and on Shells found in Gravel under the Lava, by Charles Lyell, Esq., F.G.S.

———— On the Geological position of the Bitumen used in Asphalte Pavements, by S. P. Pratt, Esq., F.G.S.

———— Letter from Capt. Cooper, announcing the Discovery of Coal, or Lignite, in the Island of Formosa.

December 3rd.—On Fossil Ferns from Maryland, by C. J. F. Bunbury, Esq., F.G.S.

———— On Bones of Iguanodon recently found in the Wealden strata of the Isle of Wight, by G. A. Mantell, LL.D., F.G.S.

December 17th.—On the supposed Fossil Bones of Birds from the Wealden, by Richard Owen, Esq., F.G.S., Hunterian Professor of Anatomy in the Royal College of Surgeons.

December 17th.—On Amber, and on the Organic Remains found in it, by Prof. Göppert of Breslau.

——————— Extract from a Letter concerning a Depression lately produced in consequence of an Earthquake in Cutch, by Mrs. Derinzy.

——————— On the occurrence of Nodules, commonly called Fossil Potatoes, on the shores of Lough Neagh, by the Very Rev. the Dean of Westminster, F.G.S.

January 7th, 1846.—On the Fossil Remains of Birds in the Wealden strata, by G. A. Mantell, LL.D., F.G.S.

January 21st.—Continuation of the Memoir on the Palæozoic Rocks of Cumberland, by the Rev. Adam Sedgwick, F.G.S., Woodwardian Professor in the University of Cambridge.

——————— On the so-called "Jackstones" of Merthyr Tydvil, by Joseph Dickinson, Esq., F.G.S.

——————— On the Coal-plants of Nova Scotia, by J. W. Dawson, Esq., and C. J. F. Bunbury, Esq., F.G.S.

February 4th.—On the Tertiary Formations of the Isle of Man, by the Rev. J. Cumming.

——————— On Sternbergia, by J. S. Dawes, Esq., F.G.S.

Trust Accounts.

Receipts.	£.	s.	d.	£.	s.	d.	Expenditure.	£.	s.	d.	£.	s.	d.
Balance at Banker's, 1st January, 1845, on the Donation Fund				31	11	6	Cost of Medal awarded to Prof. Phillips	10	10	0			
Balance at Banker's, Geological Map Fund				3	5	0	Balance of Proceeds awarded to Mr. Bain	21	1	6			
Received for Geological Map of England	53	15	0								31	11	6
Dividends on Donation Fund of 1084*l.* 1*s.* 1*d.* Red. 3 per Cents.	31	11	6				Paid on account of Geological Map				3	5	0
				85	6	6	Balance at Banker's, Trust Account				85	6	6
				£120	3	0					£120	3	0

Valuation *of the Society's Property; 31st December* 1845.

Property.	£.	s.	d.	£.	s.	d.	Debts.	£.	s.	d.
Balance in Banker's hands				338	5	2				
Balance in Clerk's hands				8	7	8	John Arrowsmith, account not yet obtained, but estimated at about	15	0	0
Funded Property, 3150*l.* 5*s.* 11*d.* Consols, at 94				2961	4	8	Balance in favour of the Society	4821	7	11
Arrears of Admission Fees	33	12	0							
Arrears of Contributions prior to 1845, considered good	6	6	0							
Arrears of Contributions of 1845	44	2	0							
				84	0	0				
Estimated value of unsold Transactions				1265	11	11				
Estimated value of unsold Transactions, separate Memoirs				78	18	6				
Estimated value of unsold Proceedings				100	0	0				
[*N.B. The value of the Collections, Library and Furniture is not here included.*]				£4836	7	11		£4836	7	11

Signed, J. L. PREVOST, Treasurer.

Feb. 2, 1846.

RECEIPTS.

	£.	s.	d.	£.	s.	d.
Arrears of Admission Fees..............	39	18	0			
Arrears of Annual Contributions	75	12	0			
				115	10	0
Admission Fees				212	2	0
Annual Contributions of 1845				740	15	6
Dividends on 3 per Cent. Consols				86	13	5
Sale of Transactions				69	19	6
Sale of Transactions in separate Memoirs				67	19	4
Sale of Proceedings				5	11	6
				£1298	11	3

	£.	s.	d.
Balance at Banker's, January 1, 1845..............	234	6	10
Balance in Clerk's hands	40	0	0
Compositions received	220	10	0
Composition received in December after Consols shut	31	10	0
Balance of Income over Expenditure as above	40	16	0
	£567	2	10

We have compared the Books and Vouchers presented to us with these Statements, and find them correct.

Signed, T. H. SHADWELL CLERKE, JOHN CARRICK MOORE, S. P. PRATT, } AUDITORS.

Feb. 2, 1846.

during the year ending December 31, 1845.

PAYMENTS.

	£.	s.	d.	£.	s.	d.
General Expenditure:						
House Repairs	5	12	1			
Furniture Repairs	23	14	6			
New Furniture	56	2	4			
Taxes and Rates	35	11	4			
Fire Insurance	9	0	0			
Fuel	45	17	0			
Light	24	9	8			
Miscellaneous House expenses, including Postages	46	14	1			
Stationery	35	6	7			
Miscellaneous Printing	33	11	3			
Tea for Meetings	25	18	8			
				341	17	6
Salaries and Wages:	£.	s.	d.			
Vice-Secretary	150	0	0			
Sub-Curator	93	15	0			
Clerk	100	0	0			
Porter	80	0	0			
House Maid	33	4	0			
Occasional Attendants	15	19	6			
Collector	28	7	0			
				501	5	6
Library				90	6	3
Museum				9	19	11
Diagrams at Meetings				1	5	8
Miscellaneous Scientific Expenditure				9	3	4
Publications:	£.	s.	d.			
Extra Charges on Journal	55	19	0			
Proceedings	155	9	8			
New Titles, &c. for the separate Memoirs of Transactions	31	9	2			
Transactions	60	19	3			
				303	17	1
Balance of Receipts over Expenditure				40	16	0
				£1298	11	3

	£.	s.	d.	£.	s.	d.
Compositions Funded				220	10	0
Balance at Banker's	306	15	2			
Balance Composition not Invested, to be Invested in January 1846	31	10	0			
Total Balance at Banker's, December 31, 1845				338	5	2
Balance in Clerk's hands				8	7	8
				£567	2	10

Estimates *for the year* 1846.

INCOME EXPECTED.

	£.	s.	d.	£.	s.	d.
Balance of 1845				40	16	0
Arrears (See Valuation-sheet)				84	0	0
Ordinary Income for 1846 estimated:						
Annual Contributions (250 Fellows)				787	10	0
Admission Fees, under the average of the last 5 years:						
Residents (15)	94	10	0			
Non-residents (14)	147	0	0			
				241	10	0
Dividends on 3 per Cent. Consols				90	0	0
Sale of Transactions and Proceedings				100	0	0
				£1343	16	0

Mem.:—

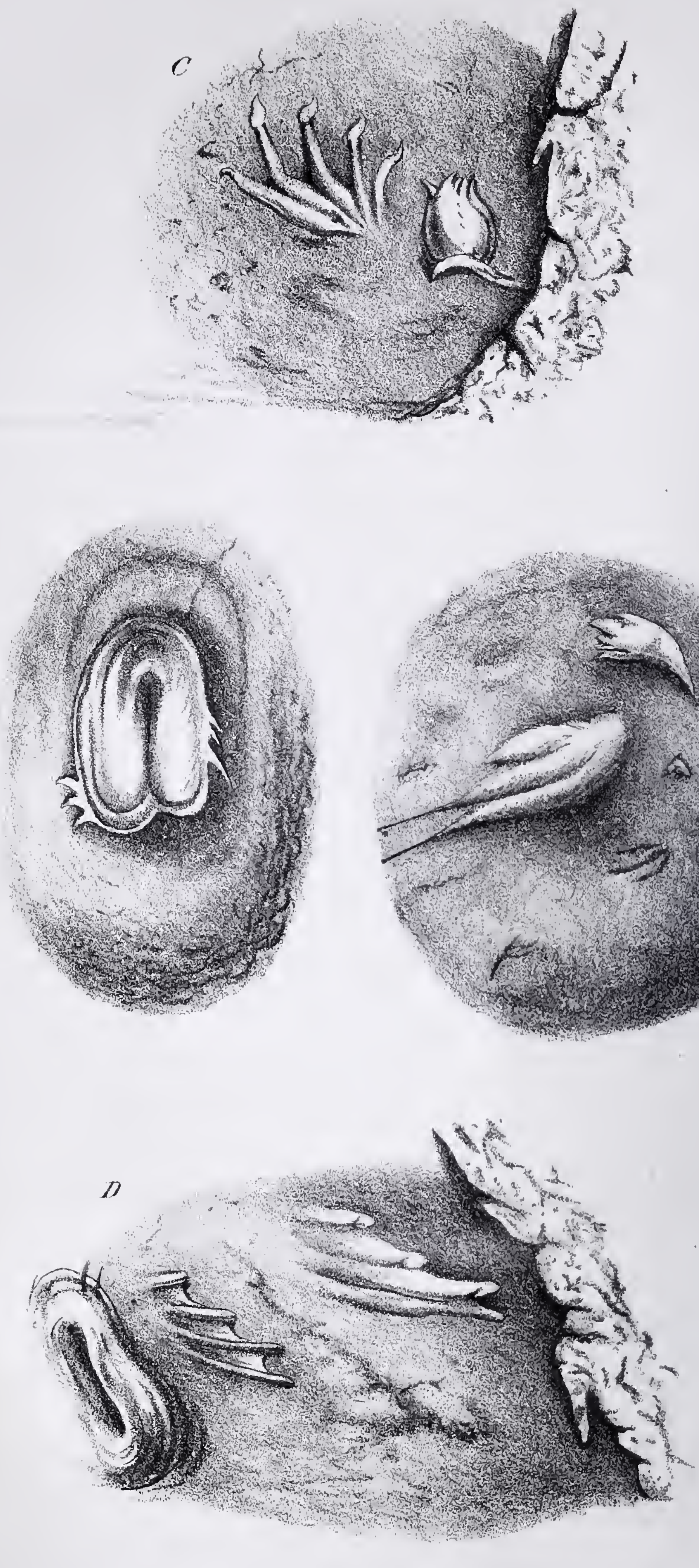
	£.	s.	d.
Balance at Banker's, 31 December, 1845	306	15	2
In the Clerk's hands	8	7	8

Signed, J. L. PREVOST, Treasurer.

Feb. 2, 1846.

EXPENDITURE ESTIMATED.

	£.	s.	d.	£.	s.	d.
General Expenditure:						
House Repairs	10	0	0			
Furniture Repairs	15	0	0			
New Furniture	25	0	0			
Taxes and Rates	35	11	4			
Fire Insurance	9	0	0			
Fuel	45	0	0			
Light	25	0	0			
Miscellaneous House Expenses	46	0	0			
Stationery	35	0	0			
Miscellaneous Printing	32	0	0			
Tea for Meetings	26	0	0			
				303	11	4
Salaries and Wages:						
Vice-Secretary	120	0	0			
Curator	130	0	0			
Clerk	100	0	0			
Porter	80	0	0			
Housemaid	33	4	0			
Occasional Attendants	16	0	0			
Collector's Poundage	30	0	0			
				509	4	0
Library:						
Catalogue	60	0	0			
Binding and Additions	50	0	0			
				110	0	0
Museum				25	0	0
Diagrams at Meetings				16	0	0
Miscellaneous Scientific Expenditure				15	0	0
Publications, Journal				200	0	0
„ Transactions				100	0	0
				1278	15	4
Balance over Expenditure				65	0	8
				£1343	16	0



Reeve, imp.

Footmarks in New Red Sandstone.

(Dr. Black.)

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

November 5, 1845.

The following communications were read:—

1. *Observations on a Slab of New Red Sandstone from the Quarries at* Weston, *near* Runcorn, Cheshire, *containing the* Impressions *of* Footsteps *and other markings.* By J. Black, Esq., M.D., F.G.S.

Plate V.

The notices of fossil impressions of footsteps in the New red sandstone are now sufficiently numerous, as well in Warwickshire and Shropshire as in Cheshire, to take away the interest of novelty from any discovery of this nature; yet I consider the slab about to be described sufficiently new to justify my laying the following account of it before the Geological Society.

The summit of the quarry of New red sandstone whence this specimen was extracted by Mr. Feraday Smith is about 100 feet above the level of the Mersey at Weston. The rock is here worked perpendicularly to about fifty feet from the top, and the seams which contain the impressions are two in number and are nearly three feet apart, the higher being twenty-four feet from the top. Both these seams consist of from half to three-quarters of an inch of reddish silty clay, upon which when soft the impressions have been made, and the lower series has larger and better-defined marks than the other. The beds dip to the south-west at an angle of about 10°, and are of a red colour and coarse grain.

The slab in question is seven feet long by three and a half feet broad. It contains none of the footprints of the so-called *Chirotherium* (*Labyrinthodon*, Owen), but is full of those of smaller reptiles, apparently both Emydian and Batrachian, besides others which may have been made by birds. It is remarkable for the singular complication of cracks it presents, these forming a net-work more elaborate than I have noticed in other specimens*. It will readily be seen from an examination of the slab that the cracks took place after the footmarks had been impressed on the marly silt, which must first of all have been slowly and quietly deposited on the firm sand beneath.

It would also appear from this slab, that after the deposition of this thin coherent bed, which would not originally have exceeded an inch in thickness, the waters must have retired for a time without reflux, and that during this time many kinds of animals, terrestrial as well as amphibious, walked over the surface, while a continued process of drying was contracting the whole surface and thus forming a net-work of cracks over it. After this process had gone on until the drying was complete, another deposit of arenaceous sediment took place, filling up the cracks and depressions of the surface and forming one homogeneous mass of sandstone.

On carefully examining the reversed impressions seen in relief on the slab, we may recognise at least four separate and well-defined kinds, besides several others which either from their minuteness or indistinctness are not easily characterized. There are also two sweeping mouldings of slight elevation that traverse the face of the specimens in oblique directions. Owing to the cracks that have taken place, the marks are often divided and sometimes are shifted laterally. This is also the case with the lateral moulding.

Of the larger footprints, there are about twenty running principally in one direction. They are disposed in parallel rows, with a distance of nine inches from the tip of one toe to that of the other in each row, while each print in the one row is placed opposite the middle point between the two others in the corresponding row. The impressions, or rather the moulds, rise above the plane of the slab for about three-eighths of an inch. The length of each footmark is two inches, and the breadth an inch and a half. The highest point in the mould (the deepest impression therefore) seems to correspond with the heel, which in several cases appears to have penetrated through the soft clayey mass to the hard sand. On each side of several of the footprints there are impressions of short toes or claws, while round the front of each there is a semicircular and shallow groove or waved hollow, such as might be occasioned by the soft mud being pressed forwards and raised by the weight of the foot.

The larger impressions (Pl. V. fig. A.) seem to be intimately connected with the two moulded tracks that sweep over the face of the slab, for these tracks run parallel and midway between the two rows of footmarks, and were evidently formed before the clay had dried.

* The slab from Hessberg, figured in Dr. Buckland's Bridgewater Treatise, offers the nearest resemblance in this respect, but is not so completely covered with the reticulations.

Of the two tracks also, one was formed before the other, since one of the footmarks in the longer track has obliterated part of the track of the other, while the longer track is seen to have intersected and to be deeper than the other.

Similar tracks seen in relief have been attributed to the tails of animals dragging over the surface of soft silt or clay, and in the present case this explanation seems satisfactory.

As to the nature and form of the animals which have left these footprints, we can perceive that they had a strong resemblance to recent Emydians in their mode of progression and in the form of the foot; and from the fulness of the relief observed, the animal must have been of considerable weight in comparison with the length of the foot. From the perfect definition of the tracks which appear to have been caused by the tail, this organ would seem to have been rather firm and short, and not long and pliant.

The second class of well-defined impressions are marked (B) in the accompanying plate. They consist of eight pairs running across the breadth of the slab without interruption; and there are also some others whose connection cannot so easily be traced. The pairs of these impressions, seemingly those of the fore and hind feet, run in an alternate and oblique direction with respect to each of the other pairs: only three toes can be readily made out in them, and they belong to the larger and most probably the hinder feet. In some places it appears that these hinder feet were not raised freely from the ground at every step, for there are slight mouldings running from the extremities of the longest toe as if it had been dragged over the soft surface. These footsteps seem to have belonged to some small species of land tortoise, and they exhibit neither the impressions of a web nor of claws.

The third class (C) exhibits six larger impressions, each accompanied by a smaller and more obscure one, and they run in one direction across the end of the slab. There are also some others of the same kind detached on other parts of the surface. These prints, like the former set, are alternate and placed diagonally towards each other. On a first inspection the larger of them resemble the impressions of the feet of some birds, the toes being free and each terminated by the well-marked impression of a claw; but the number of toes is five, placed in a radiating manner, and each print is accompanied by a smaller and fainter impression. The larger of these prints therefore appear to have belonged to the hind feet, and the smaller to the fore feet of an animal, which probably resembled the smaller Lacertians or Alligators.

The next set of impressions (D) are not so numerous as the others, or at least the progressive connection is less easily made out. A few of them however are sufficiently clear to enable us to refer them to a species of reptile different from those already noticed. Each impression exhibits four toes more or less approximated to each other, and showing indistinct marks of claws. Between the toes there may be detected traces of a web in some of the prints. This web reaches nearly to the tips, and where the toes are much

closed the web seems to have been folded in between them. These prints may be attributed to some Batrachian animal, or possibly to the *Rhynchosaurus* of Prof. Owen, and they resemble the set figured by Sir R. Murchison and Mr. Strickland in the Geological Transactions*. These latter were however from the new red sandstone of Shrewley Common, Warwickshire, and exhibited a tail impression referred to the animal of the footprints.

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2. *On the circumstances and phænomena presented by the* GRANITE *of* LUNDY ISLAND, *and of* HESTERCOMBE *in the* QUANTOCK HILLS, *compared with those which characterise the Granites of Devon and Cornwall.* By the Rev. D. WILLIAMS, F.G.S.

THE author commenced by referring to two former papers read before the Society†, in which he pointed out the condition of mountain limestone and new red sandstone at their contact with trap-rocks, and expressed his opinion that the trap was itself in great measure or entirely an altered condition of the rock which it seems to penetrate. He now states that he has found very numerous instances of similar reciprocal effects or mutual metamorphism in Devonshire and Cornwall, whenever the sedimentary strata are intersected by dykes of igneous rock, or contain it in an imbedded form, but that very different effects are observable when these strata have been invaded by so-called granite veins or vein-like processes. He proposes therefore to select two instances in confirmation of the evidence formerly adduced, and he wishes these two to be taken merely as examples. He considers the hypothesis of injection insufficient to account for the phænomena presented by the amygdaloidal traps and their association with the new red sandstone in the quarries about Exeter, Crediton and Tiverton.

The granite or syenite of Hestercombe in the Quantocks was first described, many years ago, by Mr. L. Horner‡. It is a true dyke extending at first for about a quarter of a mile in a direction north-east by east and south-west by west, cutting the slate-rocks obliquely. It may then be traced by the rubbly tillage land above in a direction due west, as far as a little glen and rivulet about a furlong and a half distant, where it occurs at the northern extremity of an old and extensively worked slate-quarry, its hard refractory nature having stopped the excavation in that direction. It there dips S.S.W. at an angle of about 40°. At the eastward quarry, where it is vertical, the slate, which abuts immediately against it, is thickly traversed by small veins of quartz, mica and oxide of iron, which give it a brecciated aspect, and the adjacent slate is highly indurated, yielding a stone useful for making hones. In this case the slate is altered to a distance of about a foot from the dyke, and the

* 2nd Ser. vol. v. pl. 28.

† *Vide* Quart. Geol. Journ. vol. i. p. 47 and p. 148.

‡ Geol. Trans., 1st Series, vol. iii. p. 338.

syenite in contact with it is softer, more schistose and finer-grained, containing also more hornblende than towards the centre. The soft and rotten condition of the granitic rock has no doubt obtained for it the name of *pottle-stone* by which it is locally known, since it was formerly wrought for pipkins and other culinary vessels.

As a granite the harder stone is durable, and capable of being rendered ornamental. It may be seen in the pillars of the west gateway and in the basement story of the mansion at Hestercombe.

The slate is very variably affected by this dyke, and the syenite itself is also sometimes more and sometimes less modified, but it is rare to find a specimen in which the two rocks are united together.

The granite of Lundy Island abuts directly against the slate as a vertical lofty wall; there are no granitic veins penetrating the slates, and there is little alteration produced in them, except a slight induration at the place of contact; while on the other hand the granite is greatly altered at the contact, and that to a distance of ten or twelve feet, gradually changing from a well-defined gray syenite through several varieties of hornblende rock to the condition of a black hornblendic trap of a somewhat schistose structure. It has not however been gradually metamorphosed, or at least there are appearances more perfectly syenitic on each side of the hornblende rock.

The granite of Lundy Island occupies a dyke or chasm having a north-east and south-west direction. It extends about three miles in length, and has a breadth of half a mile. The vertical wall which it presents ranges from the Sugar-Loaf on the east to the Rattles on the south of the island.

The author mentions another example of a true granitic dyke near Drewsteignton, on the north-east of Dartmoor. This dyke is about ten or twelve feet wide, and cuts the carbonaceous rocks transversely for about a mile in a north and south direction.

The author then referring to the domes and other masses of granite in Devonshire and Cornwall, and the numerous small veins which proceed from them, contrasts the condition both of the injected and the bounding rock in the case of these veins with that presented by the dykes just alluded to. In the former case, where the veins proceed directly from the central mass, the bounding rock is greatly metamorphosed, while the granite is little changed; in the latter, on the contrary (the dykes), it has been stated that the igneous rock is much altered and the slates simply indurated within a short distance of contact. He considers therefore that the circumstances and conditions could not have been the same in these two cases.

If (as appears to have been the case) we imagine that the granites of Lundy Island and of Hestercombe were fluid when the dykes were formed, the author considers it difficult to explain why the fluid matter did not penetrate and alter the adjacent rocks as the veins of granite have done elsewhere, unless the circumstances and conditions of the case were different.

It appears to be the opinion of the author, that the heat of the

melted rock in the dykes was insufficient to produce these effects of metamorphism, and that in the other instances a great body of igneous rock was close at hand, affording a more intense heat capable of producing the modifications observed.

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3. *On the Geology of the neighbourhood of* Tremadoc, *Caernarvonshire.* By J. E. Davis, Esq., F.G.S.

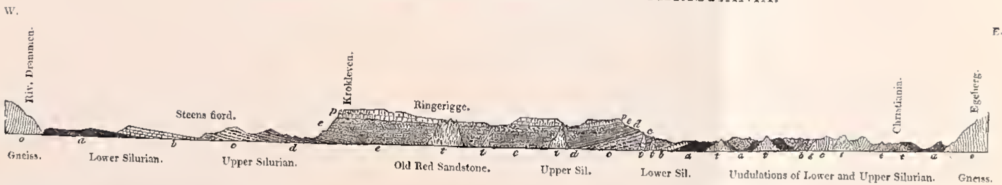
The little town of Tremadoc (in the northern part of Cardigan Bay) is beautifully situated on the north side of a valley formerly covered by the sea. Mr. Maddock having in the year 1813 made an embankment across the wider valley of Traeth Mawr, of which, on the western side, the Tremadoc valley was an inlet, the sea was barred out, the valley brought under cultivation, and the town erected. On approaching this district of Caernarvonshire from the east, it does not require the eye of a geologist to be assured that the sea once, and at a comparatively recent period, extended many miles inland. The succession of cliffs with steep escarpments facing the present line of coast, and extending inland up the eastern side of Traeth Mawr, one behind the other, for several miles, are striking features in the scenery of this romantic neighbourhood.

The stratified rocks of the district have a general strike from north-west to south-east, with a north-east dip. They consist of slates, shales, flags and sandstones, but, from the almost total absence of organic remains, the determination of the age of the beds must be a work of considerable difficulty and time, and is one in which great caution is requisite, for all these rocks have apparently undergone great change of structure in many places, and that which is the same formation or bed, presented under a new aspect, may be easily mistaken for a totally distinct deposit.

Although some of the rocks are described as slates, the slaty cleavage is too imperfect to admit of the rock being quarried for economic purposes, and true slates are not obtained nearer than Festiniog, several miles east of Tremadoc, a district to which these observations do not extend. The strata however, whether flagstone, sandstone or shale, possess in many places a distinct structure, consisting of an irregular prismatic cleavage observable in many places, the rock shivering into splinters of a foot or more in length, and from one to three inches in width. These splinters conform to the direction of the dip, and their points, as far as they have been observed, dip at the same angle. A good example of this structure is exposed by a cutting on the left side of the road leading from Portmadoc to Tremadoc, and within a few yards of the last house in the former place.

The only fossils I met with were a Lingula and traces of Fucoids, occurring in great abundance in flagstones near Penmorfa church, about two miles west from Tremadoc, and also on the south side of Moel-y-Gest. The Fucoids resemble the remains found in the Upper Ludlow rock of the Silurian system, but similar species have

IV. SECTION ACROSS THE TERRITORY OF CHRISTIANIA.



References to the above diagram :—

Old Red Sandstone—*e.* Red sandstone and conglomerate.

Upper Silurian { *d.* Calcareous flagstones, &c.
c. Coralline limestone and shale.

Lower Silurian { *b.* Pentamerus limestone.
a. Schists, flags, and lower sandstone.

o. Azoic or gneissose rocks, with old granite, greenstone, &c.

{ *p.* Rhombic porphyry in the Old Red Sandstone.
t. Eruptive and trappæan rocks of various characters.

The diagram in page 469 of the first volume of the Journal, accompanying Mr. Murchison's memoir on the Geology of Scandinavia, very imperfectly represents the interesting and remarkable phænomena exhibited in the Basin of Christiania. The original section, as given in the great work on Russia (p. 13), by Messrs. Murchison, de Verneuil, and de Keyserling, is now reprinted to justify the conclusions insisted on in the memoir alluded to, and to give an idea of the perfect evidence existing in that part of Norway of the succession there traceable from Lower through Upper Silurian to the Old Red Sandstone inclusive. The section as now given represents on a small scale, towards the right-hand side of the wood-cut, the intrusive rocks (granite, syenite, porphyries, greenstones, amygdaloids, &c.), and the effects they have produced, though it is not pretended that even a twentieth portion of the flexures and contortions are here shown.

been observed near Middleton chapel on the Comden mountain in Shropshire, occurring with *Asaphus Comdensis*, which is believed to be referable to the Llandeilo flags. These fossiliferous beds lie below the other stratified deposits of the neighbourhood.

The igneous rocks of this district may be divided into two classes. The first, consisting of a porphyritic rock, is the most extensively developed, and is intimately connected with the physical aspect of the country. This porphyritic rock occurs in large masses, forming elevated and parallel ridges extending from north-west to south-east. The most southern of these ridges in this neighbourhood forms the mountain called Moel-y-Gest, the southern boundary of the Tremadoc valley, which it separates from the sea. A second more prolonged ridge extends from near Penmorfa, and, forming the north side of the valley and the ridge called Yr Alt Wen, terminates abruptly at Tremadoc. A third ridge runs north of the last, and extending still further east, terminates in the valley of Traeth Mawr. Other ridges occur to the north, and their eastern extremities overhang the road leading from Tremadoc to Beddgelert.

A columnar structure is discernible in many places, varying in form and number of angles, but always on a large scale. Wedge-shaped forms may be observed in the cliff behind the inn at Tremadoc. Two of these wedges form a cube, and where a number of these have given way and fallen from the face of the cliff, a smooth surface is presented, having the appearance of a plane of a highly inclined and nearly perpendicular stratum. Westward of this spot the columnar structure is more readily traced.

The eruption of these rocks was subsequent to the consolidation of the adjacent stratified deposits. This is clearly proved by the effect of their intrusion upon the adjoining strata, and by the position of the beds near and at the points of contact. A few yards east of the inn at Tremadoc, and some hundred feet above the road, the beds of coarse slate or flagstone are nearly vertical. In Moel-y-Gest beds of slate may be seen jammed in between two masses of basalt, and dipping at a very great angle to the east. In the ridge of Yr Alt Wen the intrusive rock appears to have been forced up between beds of sandstone; and it is singular, that while the lower beds do not appear to have been materially affected, the superincumbent mass is much altered, and assumes the splintery structure before noticed. In flagstones also, reposing on the north side of one of these ridges, near Port Treuddyn, and adjoining the road leading from Tremadoc to Beddgelert, about a mile and a half from the former place, the effects of the intrusion are discernible to the distance of many feet from the point of contact by discoloration and partial fusion.

It will be seen that the general strike of the stratified rocks corresponds with the line of irruption, and it seems to be a reasonable inference that the latter was the cause of the former. At the same time it is to be observed that this strike and north-east dip prevail to the shore of Cardigan bay, and further south than any line of igneous rock observed by me.

Besides these main lines, smaller outbreaks occur in the vale of Tremadoc, and may be traced in some of the little hillocks or mounds which form such striking objects in the valley, and which, previously to the erection of the embankment, were islands in the bay. Out of seven of these islets or hillocks, *three* were found to be composed of dykes of the same character, and apparently of the same age as the more elevated and extended lines forming the boundaries of the valley. In two of these three islands, Yns hir (Long Island), and Yns cerig duon (the Island of the black stone), it occurs in dykes crossing the slates. In the third, Yns cerig aethnen (Island of the shaking stone), it is stratified conformably with the overlying and underlying slates, but has evidently been forced up between the beds of rock, after the solidification of the latter. The slates on both sides are altered to a considerable distance, and the porphyritic rock contains numerous fragments of that formation. The upper beds are decomposing. The entire thickness of the intrusive rock in this place is about twenty feet.

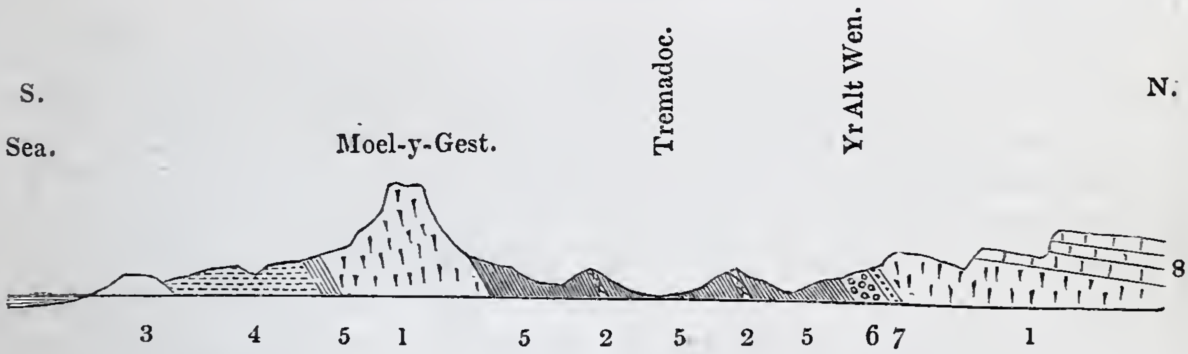
In the other islands visited the second class of igneous rocks, comprising beds and dykes of clink-stone, occur. The traces of the igneous origin of these rocks were so striking, that it was with difficulty I could persuade myself that I was not standing on the ruins of an ancient furnace; and even when I ascertained beyond a doubt the volcanic origin of the igneous matter around me, it was a considerable time before I could bring myself to assign to these rocks the very remote origin which repeated observations at last compelled me to do. Like the porphyritic islands, the clink-stone occurs in dykes and also in conformable beds, but the analogy between the two descriptions of igneous rock ceases here. While the effects of the porphyry upon the adjacent beds are only seen upon close inspection and comparison of different portions of the latter, the effect of the clink-stone is of the most marked and striking character. Dark blue slates are turned red or black, are vitrified and calcined for the distance of several feet, and exhibit between their laminæ all the hues of the rainbow; and in the little islet near the farm-house called Pen sy flog, where the clink-stone occurs in a stratified form, there is this important distinction, viz. that while the slate upon which this rock-stone rests is affected, as in the instance of the dykes, and the stratum of slate immediately under and in contact with it is changed into a light ashy substance with white flakes (resembling the ash of inferior kinds of coal), the superincumbent strata are scarcely, if at all affected. No fragments of slate-rock were observed in the volcanic matter.

The igneous rocks of both descriptions, and in the mountain ridges as well as in the islands, are traversed by numerous veins of quartz in large crystals. In a dyke of the clink-stone, about a quarter of a mile from Tremadoc, on the left side of the Old Caernarvon road, in addition to these phænomena, I observed the edge of a bed of scoriæ jutting out on the escarpment and former sea-cliff. The volcanic cinders, sand, &c. are clearly discernible, as if the result of an irruption of yesterday. I could not observe any important devia-

tion from the usual north-east dip of the slates, produced by the intrusion of the clink-stone. A folding over of a few feet of the slates, the result perhaps of lateral pressure, exhibited by the cuttings of a mining level at the spot last mentioned, was the effect, and the only effect of this nature which came under my observation. These irruptions of clink-stone are associated with only one and the same sedimentary rock, consisting of imperfect shivery slates, totally devoid of organic remains.

It has already been mentioned that the lower lands of the district present the appearance of having been covered by the sea at no very remote period; and repeated observations, and the evidence of the inhabitants, all tend to the inference that the land has gradually emerged from the sea, and that a movement of this kind is still in operation. The evidence also, that the higher ridges derive their present configuration from the action of water, is very striking. The curved line between one ridge and another (as seen in the

SECTION in the neighbourhood of TREMADOC.



8. Flagstone.
7. Sandstone.
6. Flags.
5. Slates.
4. Flagstones with *Lingula*, &c.
3. Quartz-rock.
2. Clinkstone.
1. Porphyry.

section) is evidently owing to the denudation of the stratified, and therefore softer rocks, which have escaped denudation only in those parts where they have been protected by the superincumbent porphyry (1), or where they have been hardened by immediate contact with it, and have thus resisted the action of the waves.

Along the sides of the porphyritic ridges, a vast talus has accumulated, the effect of the long-continued disintegrating action of rain and frost. A striking example of this talus occurs on the left of the road leading from Tremadoc to Beddgelert, columns of the porphyry of immense size being there piled one above another from a great depth, reaching two-thirds of the height of the perpendicular cliff. Large masses are falling every year, and will inevitably continue to do so until the process of destruction is put an end to by the talus attaining the level of the cliff. This is already the case in the ridges furthest removed from the present sea-level.

In witnessing the slow but certain destruction of the porphyritic ridges by atmospheric action, it is impossible not to be struck with the change which has taken place in this respect between the porphyry and the accompanying slates. When both were exposed to the action of the superincumbent waters, the denudation of the slates and sandstones proceeded rapidly, and was only impeded by the

protecting power of the harder igneous rock. In the elevated ridges of porphyry, the process of destruction and the consequent accumulation of the talus is now occasionally prevented by masses of slate in front of the cliff, the remaining evidence of their former denudation.

If it be assumed, as may fairly be done, that this talus dates its origin or commencement of accumulation from the period when the sea ceased to flow at its base, we are furnished not only with data on which to found an approximation with regard to the time which has elapsed since, but also with a proof of the gradual nature of this change; for if the sea were removed at one and the same time, from the lowest as well as the highest ridges, the talus would be equal, or at least in proportion to the respective heights of the cliffs; whereas the fact that the talus is greatest and has generally reached its ultimate limit in the cliffs situated at a greater distance from the sea, is evidence that the process of accumulation has been going on for a longer period, and is consistent with the theory of a gradual elevation.

The evidence of the still more recent and continued elevation of the coast is derived from the embankments which have from time to time been made since the sixteenth century. These embankments, commencing high up the Traeth Mawr, have been succeeded by others lower down, and as the new were secured the older became useless. It is evident that these embankments are not the sole or principal cause of the sea no longer flowing within them, but that the natural recession of the sea (or elevation of the land) induced the inhabitants to anticipate, by the erection of earthen mounds, that which would have been produced in a few years by other causes. The sea-mark may be traced on the surface of the escarpments in several of the islands in the Tremadoc valley, many feet above the present level of high water.

Tradition also lends its aid. From the rocky ground of Yns hir, Madoc, one of the princes of North Wales, leaving his native country, *sailed* to unknown lands*. And to descend to more recent times: I was informed that the parish register of Penmorfa contains entries showing that a place in the parish called Y wern was once a seaport, which immediately before the erection of the great embankment was several feet above high water.

The river, generally known to Welsh tourists as the Pont Aberglasllyn river, instead of taking its present direct course, flowed round the Tremadoc valley, and the soil of the upper part of the valley is composed of peat and decayed vegetable matter, probably deposited from the fresh water, the spot being protected from any strong tidal action. The river appears to have assumed its present course before the erection of any embankment.

The successive geological changes which these observations suggest as having taken place in this district appear to be—

First, The accumulation under water of sedimentary deposits, containing a few organic remains referable to the Silurian period,

* It is on this tradition that Southey founded his poem of 'Madoc.'

and this accumulation accompanied by occasional volcanic outbreaks near the surface, producing merely local dislocation, probably followed by a general depression.

Secondly, The contemporaneous disturbance and upheaval of the whole district by the intrusion of a volcanic rock in nearly parallel lines from south-east to north-west, causing an inclination in the stratified rocks to the north and north-west, and followed by great denudation.

And thirdly, The gradual elevation of the whole country, continued to the present time, by which the present physical appearances were produced by the denudation of the softer rocks, leaving the porphyry in elevated mountain ridges (which have been since materially acted upon by the atmosphere), and leaving insulated masses of the volcanic rock of the earliest period.

November 19, 1845.

The following communications were read:—

1. *On the Age of the newest Lava Current of* Auvergne, *with remarks on some Tertiary Fossils of that Country.* By Charles Lyell, Esq., M.A., F.R.S., F.G.S. &c.

Until my recent visit to Auvergne in 1843, I was never able to hear of the discovery of any fossils so connected with the most modern class of volcanic cones and currents of lava, as to enable us to assign to them any other than a very indefinite geological date. But when in the course of my last tour I inquired of the Abbé Croizet, well known as an eminent comparative osteologist, if he had yet found any fossil bones or shells in gravel lying immediately under the newest lava-streams, he replied that he had recently met with a great number of mammiferous remains at Nechers, in a bed of reddish sandy clay, which rested against the side of the long and narrow coulée which has issued from the Puy de Tartaret. This hill, as the readers of Scrope's 'Geology of Auvergne' will remember, is one which, by its position in the bottom of a valley at the lower end of the Lac de Chambon, and by the integrity of its heap of loose scoriæ, has all the characters belonging to the class of most modern cones, those which have been least altered by time. The lava issuing from it forms a narrow stripe, occupying for more than thirteen miles the bottom of the valley in which the river Couze de Chambon flows, and at length terminating at the small town of Nechers, about six miles north-west of Issoire. At a short distance above the end of the current in the suburbs of the town, the lava at its side presents a steep and often perpendicular face, twenty-five feet in height towards the river, a meadow only intervening between it and the banks of the Couze. Most of the bones of fossil quadrupeds had been found in a superficial deposit of red sandy clay in this meadow;

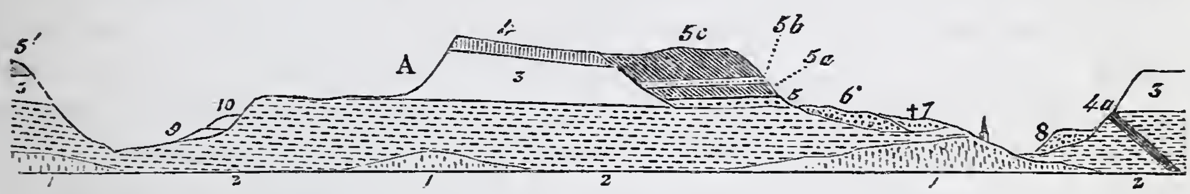
but on closely examining the spot in company with M. Bravard the palæontologist, and with M. Croizet, I became convinced, and both these gentlemen are now of the same opinion, that the deposit in question passed continuously under the lava, containing beneath it the same fossils as in the meadow. This fact was made clear by a cave serving as a wine-cellar excavated artificially under the lava; and it has since been more completely established by the investigations of M. Bravard, who will, I believe, soon publish an account of several sections and of the fossil remains. I have little doubt that the current of lava itself once extended farther northwards towards the river, and covered part of the bone-bed which is now exposed. The only fossils which I collected on the spot consisted of the jaw and teeth of a species of *Arvicola*, and the molar of a horse, which Mr. Owen has since examined, and remarks that it agrees precisely with the third lower molar of his *Equus fossilis* from the caves of Oreston (see 'British Fossil Mammalia,' p. 387, fig. 145); showing the same difference from the corresponding tooth in the recent horse in its narrower transverse diameter, which he has figured in his 'British Fossil Mammalia.' The other species found in the same argillaceous sandy bed are referable to the genera *Sus*, *Bos*, *Cervus*, *Felis*, *Canis*, *Martes*, *Talpa*, *Sorex*, *Lepus*, *Sciurus*, *Mus* and *Lagomys*. The bones also of a frog, snake and lizard, and of several birds are associated: in all no less than forty-three species have been brought to light, all closely allied to recent animals, yet nearly all of them, according to M. Bravard, showing some points of difference, like those which Mr. Owen discovered in the case of the horse above alluded to. Several recent land-shells, such as *Cyclostoma elegans*, *Helix hortensis*, *H. nemoralis*, *H. lapicida*, *Clausilia rugosa*, and others, accompanied the bones. M. Croizet has also mentioned to me the horns of a rein-deer found in the meadow. It is highly probable that these animals may have been drowned by floods which accompanied the earthquakes and eruptions by which the Puy de Tartaret was formed: at all events, we may affirm that they belong to the alluvial formations of the river-bed and river-plain which existed at the time of the flowing of the lava of Tartaret, and they consequently give an exceedingly modern geological date to that lava, though we must still infer, that the current was produced at an æra when the mammiferous fauna was very distinct as a whole from that now inhabiting Auvergne.

That the current which has issued from the Puy de Tartaret may nevertheless be very ancient, in reference to the events of human history, we may conclude from the fact, that a Roman bridge of such form and construction as continued in use down to the fifth century, but which may be older, is now seen at a place about a mile and a half from St. Nectaire. This ancient bridge spans the river Couze with two arches, each about fourteen feet wide. These arches spring from the lava on both banks, showing that a ravine precisely like that now existing had already been excavated by the river thirteen or fourteen centuries ago. The bridge is still in use, but the arch on the right side of the river has been half blocked up

by the fall of masses of lava from the cliff above. On the whole, therefore, if we take the Puy de Tartaret and its lava as a type of the products of the most modern volcanoes of Auvergne, we may infer, from the facts above described, that the latest eruptions occurred at the close of the Newer Pliocene, if not in the Post-pliocene period, or when the mollusca were identical with those now living, although a great many of the mammalia belonged to species now extinct.

Section from the Valley of the Couze at Nechers, through Mont Perrier and Issoire to the Valley of the Allier, and the Tour de Boulade, Auvergne.

Couze R. Mont Perrier. Issoire. Tour de Boulade.



10. Lava current of Tartaret near its termination at Nechers.
9. Bone-bed, red sandy clay under the lava of Tartaret.
8. Bone-bed of the Tour de Boulade.
7. Alluvium newer than No. 6.
6. Alluvium with bones of hippopotamus.
5 *c*. Trachytic breccia resembling 5 *a*.
5 *b*. Upper bone-bed of Perrier, gravel, &c.
5 *a*. Pumiceous breccia and conglomerate, angular masses of trachyte, quartz pebbles, &c.
5. Lower bone-bed of Perrier, ochreous sand and gravel.
4 *a*. Basaltic dyke.
4. Basaltic platform.
3. Upper freshwater beds, limestone, marl, gypsum, &c.
2. Lower freshwater formation, red clay, greensand, clay, &c.
1. Granite.

A. At a point corresponding to this, and situated on the north side of the hill of Gergovia, the *Melania inquinata* has been found in freshwater marl under basalt.

In the accompanying section I have shown at the north-west extremity the position occupied in the valley of the Couze at Nechers by the lava of Tartaret, No. 10, and subjacent bone-bed No. 9. I have at the same time shown, in the prolongation of the same section to the hills on the right bank of the Allier, near Issoire, the position of various other superficial deposits in which MM. Croizet, Bravard, Pomel and others have detected mammalian remains belonging each of them to very distinct assemblages of species, and which have doubtless originated at successive tertiary epochs. In the oldest freshwater tertiary beds, Nos. 2 and 3, the *Palæotherium*, *Anoplotherium*, *Anthracotherium*, *Didelphis*, *Crocodile*, and other genera common to the Paris basin, have been found associated with species of *Rhinoceros*, *Cervus*, and some other genera, which, in Cuvier's experience, had never been met with together in the same formation. Above these rests a sheet of basalt, No. 4, forming the north-west portion of the summit of Mont Perrier. In many places similar elevated basaltic platforms rest on gravel-beds, in which fossil mammalia have been detected. Next in age are the trachytic and pumiceous breccias and accompanying gravel-beds, 5, 5 *a*, 5 *b*, 5 *c*, which were described by Sir R. Murchison and myself in a paper published in 1829 in the Edinburgh New Philosophical Journal for July. In the alluvial deposits 5 and 7, bones have been obtained belonging to the genera *Mastodon* (2 species), *Rhinoceros*,

Tapir, *Sus*, *Bos* (2 species), *Cervus* (about 20 species), *Antilope*, *Capra* (2 species), *Felis* (7 species), *Hyæna* (2 species), *Martes*, *Lutra*, *Canis*, *Ursus*, *Erinaceus*, *Marmot*, *Castor*, *Arvicola* (2 species), and *Lepus*, all referable to extinct species. Next in age come two other alluvial deposits, Nos. 6 and 7, in which fossil mammalia of other species, according to M. Bravard, occur, the bones of *Hippopotamus* in particular having been met with in No. 6. Passing then to the south-east of Issoire, and crossing the Allier, we arrive at No. 8, the celebrated bone-bed of the Tour de Boulade, in which a great many other mammalia have been collected by the labours of MM. Bravard and Pomel; among others the *Elephant*, *Rhinoceros* (*R. tichorhinus*), *Equus*, *Bos*, *Cervus* (including Reindeer), *Antilope*, *Felis*, and *Canis*. This assemblage differs considerably in its species from any other in the neighbourhood, and may be considered as more ancient in character than No. 9, alluded to in the beginning of this paper, or the bed which underlies the lava at Nechers. In regard to the Tour de Boulade bed, No. 8, its base is about sixty feet above the level of the Allier. It consists in great measure of angular pieces of freshwater limestone and basalt, which seem to have fallen from the steep slope of the hill above, or which at least are unrounded, and have not been brought from a distance. Some of the angular blocks are three feet in diameter. There is an intercalated sandy bed with bones such as may have been deposited in a river or sheet of water, into which these fragments of rock, detached by frost from the precipice, have rolled down. In this sandy stratum two marine shells have been found by MM. Bravard and Pomel, belonging decidedly to the genera *Natica* and *Pleurotoma*. Although too imperfect to allow of the species being positively determined, they both approach closely to shells which I have from the faluns of Touraine. As no marine tertiary shells had been previously observed nearer to this part of Auvergne than the valley of the Loire, and as the deposit under consideration has a purely terrestrial or supra-marine aspect, I should not have given credit to this discovery if not attested by geologists, who are so cautious, and who were so alive to the novelty and importance of the phænomenon at the time when they found them, as were the naturalists above mentioned. They have been as much perplexed as I am to conceive how any current of water could have brought such shells from the north; and we can hardly suppose the Miocene sea to have ascended the valley of the Allier without leaving there some more decided monuments of its sojourn.

There is only one other subject on which I shall offer a few observations. It has long been announced, that in the celebrated mountain of Gergovia M. Bouillet had found the *Melania inquinata* in some argillaceous marls in the north flank of the hill. I examined the spot with attention, and obtained by digging many specimens of the *Melania* in question, and of a *Unio* and *Melanopsis* which accompanied it in abundance. Some doubts had been raised by M. Bouillet whether the strata containing these shells belonged merely to a local deposit, or really formed an integral part of the great freshwater formation of Auvergne, of which the mass of the hill of

Gergovia is composed. I consider the section however as perfectly clear, and the *Melania* and other fossils are evidently imbedded in a stratum, which crops out from beneath the capping of basalt which constitutes the flat summit of the mountain. It will be unnecessary to give a separate section, because the position of the beds is fully indicated by the point A, which I have placed in the upper freshwater strata below the basalt on the steep north-west slope of Mont Perrier. Many palæontologists who had been inclined to regard the strata of the Limagne as considerably newer than the tertiary beds of any part of the Paris basin, had been surprised that a fossil eminently characteristic of the lower part of that basin, and found also under similar circumstances in the plastic clay of the London basin, should occur in the highest beds at Gergovia. I find however that all these Auvergne shells belong, if not to a distinct species, at least to a perfectly different variety from that found in the neighbourhood of Paris and London; and what renders the fact still more interesting, it is a variety which can hardly be distinguished from the recent Melania of the Philippine Islands, which M. Deshayes first identified with the Parisian fossil. Mr. G. B. Sowerby, in the Malacological Magazine, part 1, 1838, pointed out the differences existing between all the varieties of the Eocene *Melania inquinata* then known, and the varieties of the recent shell, which he proposed to name *Melania Philippinarum*; but he now admits that the most marked of these points of difference cannot be detected in the specimens I brought from Gergovia, which, although they may not be perfectly identical with any one variety of the living species, would yet be considered by most conchologists as merely another variety of the same. The most obvious distinction between the ordinary Paris or London basin fossil, from the living Melania of the Philippines, consists in the absence in the former of those spiral ridges or raised striæ which in the living shell intervene between the principal row of tubercles in each whorl and the suture. In all the fossil individuals from England and the Paris basin these are wanting, although I possess one specimen given me by M. Graves from the department of the Oise in which the striæ are visible, though obsolete, a fact to which Prof. E. Forbes called my attention, and which may lead us to suspect that a series of intermediate gradations may one day be detected between the Parisian (Epernay), the Gergovian and the recent shell. In the meantime, however, we may regard the Auvergne and Philippine Island species, both in the form of the volutions, the prominent striæ above mentioned and other characters, as belonging to one type, while the fossils of the Paris and London basins are referable to another. If all could be regarded as one species, its changes may be compared to those which the *Cardium porulosum* undergoes, as M. Deshayes has shown, as it appears successively in the sands of the Soissonois, in the calcaire grossier, and in the upper marine formation near Paris. No argument can therefore be founded in favour of the identity in age of the Parisian and Gergovian beds from the occurrence in both of this Melania, as the Auvergne variety is so distinct. This modi-

fication in form would be quite natural on the supposition that the freshwater beds of Auvergne were referable to the Miocene epoch. The Melanopsis associated with the Melania in the hill of Gergovia is more allied to the *M. Dufourii* than to *M. buccinoides*; the Unio seems peculiar at present to the locality. In regard to the age of the Auvergne beds generally, I have not yet seen sufficient reason, whether from the nature of the mammalian, reptilian, conchological or vegetable remains imbedded in them, to abandon the idea of their being Eocene, although it is true that they exhibit some characters in common with the Miocene period.

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2. *Geological Position of the* Bitumen *used in* Asphalte Pavements. By S. P. Pratt, Esq., F.R.S., F.G.S. &c.

The bitumen which has been so extensively used for pavements, &c. is found in considerable abundance, and of the best description, at Bastenne, a small village in the south of France, about fifteen miles north of Orthez. The geological circumstances connected with its appearance being somewhat interesting, a short account of them may be desirable.

The country about Bastenne is formed of numerous small conical hills two or three hundred feet high, separated from each other by deep narrow valleys or ravines; they are chiefly composed of a coarse sandy limestone, which M. de Fresnoy places in the cretaceous system; their upper part consists of variously coloured sands and clays from fifty to sixty feet in thickness, the whole being covered by gravel and sand, which extends for many miles in every direction. The sands and clays are usually horizontal, but are occasionally much disturbed and highly inclined; whenever this occurs it is evidently owing to the protrusion of igneous matter, which is then found in connexion with them. The bitumen is worked in three localities near to each other, and the following section was made at the principal mine:—

Gravel.

12 feet of yellow sand, consisting of numerous thin layers, varying in colour—red, yellow and white.

2 feet of red and green clay.

24 feet of coloured sands as before.

1 foot of clay.

6 feet of sands as before.

4 feet of blackish sand containing a small quantity of bitumen.

5 to 15 feet of bitumen which varies much in character, the upper part consisting of looser and coarser sand, with a less proportion of the bitumen, while the lower part is more compact, containing finer sand, and being chiefly composed of bitumen.

10 or 15 feet of sand without bitumen occurs in some places, although where the bituminous sand is found of the greatest thickness, it then rests upon the sandy limestone, which forms the chief part of the surrounding country.

This section was taken on the side of the hill where the bitumen crops out, the upper beds being cut through to expose the bed; its extent is about 2000 feet by 900; it terminates suddenly in one direction, as the horizontal strata are cut off by a fault, by which the beds are elevated to an angle of 70° or 80°.

In the sands and clays no fossil remains have been met with except occasionally small pieces of lignite, and the bitumen is generally free from any extraneous matters, except in two localities, where numerous marine shells are found, which may be referred to the miocene period. In one of these, where the bed of bitumen is from ten to twelve feet thick, the shells are disposed in numerous layers at a few inches' distance from each other,—the shells of the same kind generally forming distinct layers, although occasionally, where the layer is thicker, many species occur together: where the mass has been cut through vertically, the appearance is very striking, bright white lines appearing on the black bed of bitumen. The shells are not broken or disturbed, nor are the valves separated from each other; they are, on the contrary, perfectly preserved, the most minute markings appearing upon them when freshly dug up, but (in consequence of the loss of the animal matter) they fall into powder upon being exposed to the air. Notwithstanding this, perfect casts may be readily procured, as they easily separate from the sandy mass. The bitumen has evidently been forced into them in a soft or liquid state, as the smallest cavities are filled, and this must have taken place after their deposition in the sands in which the animals lived. The date of this formation (as indicated by the numerous species which have been determined) may be referred to the miocene æra; and as the eruption of bitumen is evidently connected with the appearance of the *ophite*, an igneous rock, which has produced such great changes in the Pyrenees, a limit may thus be obtained for these changes. The bitumen worked in the other localities appears under similar circumstances, except that no shells have been found in it; the bed is nearly horizontal, dipping slightly towards the centre, where it becomes of greater thickness; indeed it is said the depth has not been reached in one part where it is generally supposed to have risen from beneath. The bitumen is easily cut when first exposed, but in a few days it hardens so much as to become incapable of purification; the purification is effected by boiling the sandy mixture in a large quantity of water two or three times, when by continued and careful stirring the sand gradually settles to the bottom, while the pure bitumen rises to the surface and is taken off.

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3. *On the Occurrence of* Coal *in* Formosa. By — Cooper, Esq.

Specimens of this coal were exhibited to the meeting, but it did not appear from the notice under what geological conditions the coal existed.

December 3, 1845.

James Ashwell, Esq., B.A., and A. W. Jackson, Esq., were elected Fellows of the Society.

The following communications were read:—

1. *On some remarkable* Fossil Ferns *from* Frostburg, Maryland, *collected by* Mr. Lyell. By C. J. F. Bunbury, Esq., F.G.S.

Plates VI. VII.

The first of the fossil Ferns (see Plate VI.) which I wish to bring under the notice of the Society has so great a resemblance to the *Diplazites emarginatus* of Göppert*, that I doubt whether it can with propriety be considered as a distinct species. The specimens are however much more complete than the one he has figured, and in particular exhibit the fructification in a far more distinct and satisfactory manner; and this fructification clearly proves, as I think, that the plant has no close affinity with the recent genus *Diplazium*, to which Göppert referred it chiefly on account of its venation. The specimen figured by that distinguished author, and which was the only one he had seen, was procured from the neighbourhood of Ilmenau, and exhibited only two or three detached pinnæ, without any portion of the rachis; one of those pinnæ was partly covered with granulations, exhibiting no distinct structure or arrangement, which he believed to be the fructification in an over-ripe state, having lost (as often happens in ferns) all trace of its original arrangement.

In the specimens from Frostburg, the rachis or main stalk is flat, from one-eighth to one-fifth of an inch in breadth, faintly striated, and marked with small depressed dots, which doubtless indicate the insertion of hairs. The frond appears to have been simply pinnated. The pinnæ are closely set, at right angles or very nearly so to the stalk, to which they are attached by nearly the whole breadth of their base, not in the least dilated or decurrent in that part, ligulate in their general outline, rounded at the end, rather convex, about two and a half inches long, about half an inch broad, and of equal breadth through nearly their whole length; their margins regularly and neatly crenated, with shallow sinuses. The primary veins, which proceed at first rather obliquely from the midrib of each leaflet, but soon take a direction nearly perpendicular to it, are pinnated, with numerous, alternate, very oblique branches or veinlets, most of which reach the margin at an angle not far from a right angle. So far the venation agrees with that of Göppert's *Diplazites*, and of Brongniart's *Pecopteris longifolia*; but in this Frostburg plant, if I am not mistaken, the lowermost pair of veinlets belonging to each primary vein, instead of proceeding to the margin, meet the lowermost branches of the next veins, at a very acute angle, as in the recent genera *Anisogonium* and *Nephrodium* of Presl. Unfortunately, the veins are but faintly and obscurely marked in the

* Systema Filic. Fossil. p. 274. tab. 16. fig. 1 & 2.

specimens before me. In Göppert's figure, indeed, of *Diplazites emarginatus,* some of the veinlets are represented as meeting each other in the manner I have described, but in the description he states that they all reach the margin of the frond.

The fructification, which is very conspicuous in some of our Frostburg specimens, has the appearance of small, crowded, roundish spots (*sori*), placed with considerable regularity in double rows between the primary veins. Some of the pinnæ are entirely covered with it except at their extreme margins; on one it occupies the upper part, from about the middle to within a short distance of the extremity.

As Göppert himself ascribes the confused manner in which the fructification of his *Diplazites emarginatus* covers the frond, to its advanced stage of maturity, it is very possible that, in an earlier state, it might have been arranged in the same manner as in our plant. In that case there would be no difference between them, except, perhaps, in the angular confluence of the lower veinlets. I say perhaps, because his own plate is at variance with his description in that particular. The pinnæ of our plant are not indeed emarginate at their extremities, but neither are they represented so in his figure.

The *Pecopteris longifolia* of Brongniart (*Diplazites longifolius* of Göppert) differs from ours in its much narrower pinnæ, as well as in all its veinlets being free, and perpendicular to the margin.

If now we compare our Frostburg fossil with recent ferns, we see that the round sori remove it altogether from the group to which *Diplazium* belongs, and would lead us to look for its affinities among the *Polypodeæ* or *Aspideæ.* The genera *Goniopteris* and *Nephrodium* (as limited by Presl) have a venation nearly resembling that of our plant, except that the veinlets are less oblique; in the former genus there is a farther similarity in the arrangement of the sori, in double rows between the primary veins. I do not, however, know any species of either genus that comes sufficiently near, as a species, to our plant, to be worth comparing with it.

As the generic name *Diplazites* is thus shown to be inapplicable to this fern, we must either give it a new generic name, expressive of its apparent affinity with *Goniopteris,* or place it in the large and miscellaneous genus *Pecopteris,* next to Brongniart's *P. longifolia.* The latter will be, for the present, the safer plan, for much confusion and error may be produced by hasty attempts to refer the fossil ferns positively to recent genera; and Pecopteris, though a heterogeneous assemblage, at least possesses definite and intelligible characters, which is more than can be said for most of the genera that have been formed out of it. As it appears most probable that the species is the same as Göppert's *Diplazites emarginatus,* the specific name (though not particularly appropriate) must be retained, at least provisionally; and it may stand as*

* It might form a distinct section of the genus, to be called *Goniopteridites.*

1. Pecopteris emarginata.

Plate VI.

P. fronde pinnatâ (?): pinnis ligulatis obtusis late et obtusissime crenatis; basi subcontractis; costâ validâ apice attenuatâ; venis costæ subperpendicularibus pinnatis; venulis valde obliquis, infimis in angulum acutum confluentibus; soris rotundis confertis inter venas biserialibus.

2. Pecopteris elliptica (n. sp.).

Plate VII.

P. fronde bipinnatâ: pinnulis ellipticis oblongisque convexis integerrimis apice rotundatis basi contractis discretis remotiusculis; venis obliquis prope basin furcatis; soris subrotundis confertissimis.

This plant, from the same locality as the foregoing, appears to be new; at least I can find no description or figure well-agreeing with it in the works of Brongniart, Lindley and Hutton, or Göppert. The figure of *Pecopteris adiantoides* (Fossil Flora, vol. i. t. 37) has most resemblance to it in the form of the pinnules; but neither the plate nor the description of that species gives sufficient details to enable us to say whether it be the same. The fructification of *P. adiantoides* appears to be unknown.

The frond of our plant is apparently bipinnate. The insertion of the pinnæ on the main stalk is not very satisfactorily shown in our specimens, but there are no appearances indicating that they were decurrent along it, as in *P. gigantea.* The barren pinnules are considerably convex, wider apart than in most species of Pecopteris, quite distinct from one another, and contracted at the base, so that their form is pretty accurately elliptical, though rather oblique. The veins are similar to those of *P. gigantea*, except that the forking takes place very near to the midrib. The fructiferous pinnules are rather longer and narrower than the others, and of more equal breadth throughout, oblong rather than elliptical, and more suddenly contracted at the base. The fructification covers their whole surface, obliterating the side veins, and almost the midrib; it has the appearance of roundish spots, so much crowded that their arrangement is scarcely distinguishable; but I think I can perceive traces of their having formed two rows on each side of the midrib. On one of the pinnæ in a specimen in my possession, part of the pinnules are barren and part fertile, so that there can be no doubt of their belonging to the same plant.

I am not acquainted with any recent fern which closely resembles this species; but its nearest affinities are probably to be sought among the *Polypodeæ, Aspideæ,* or *Cyatheæ.* In very many ferns of these tribes, the fructification is at first in distinct spots, which become confluent when they have attained to maturity, and cover the under side of the frond almost entirely; and such appears to have been the case in the plant before us.

The third of these fossil ferns which I would mention is not indeed in a very satisfactory condition, but I have thought it worth noticing on account of its very remarkable fructification. It nearly agrees (except in size) with the *Danæites asplenioides* of Göppert*;

* Systema Fil. Fossil. p. 381. tab. 19. fig. 4, 5.

and as the specimen figured and described by that author is still more incomplete than Mr. Lyell's, so that one can hardly either distinguish or identify them with certainty, I think it safer to consider them provisionally as the same species. Our Frostburg plant will therefore stand as

3. Danæites asplenioides *var.* major.

The frond appears to be bipinnate, and if a flattened stem (apparently the stipes of a fern) which occurs in the same slab belonged to this plant, it was of large size, for the stem in question, in its compressed state, measures an inch and a half across. The pinnules are closely set, oblique, rounded at the end, slightly combined at the base, but neither dilated nor decurrent, of an oblong or broadly linear form, flat, or scarcely convex, about $\frac{4}{10}$ths of an inch long, and about half as much in breadth. Veins very indistinctly marked, but seemingly nearly perpendicular to the margin. The fructiferous pinnules (which are on a separate pinna, but which I believe to belong to the same species) are rather larger than the others, but of the same shape; the fructification has the appearance of linear masses, placed parallel and nearly contiguous to one another, perpendicular to the midrib, and extending from it quite to the margin. Its general resemblance to the fructification of the curious genus *Danæa* is very striking, but I am not quite satisfied that it is really of the same nature; for on a close examination one may detect traces of round spots; and perhaps the apparently linear masses may have been made up by the aggregation of numerous round ones.

Göppert has not figured the barren pinnules of his *Danæites asplenioides*; the fertile ones represented in his plate differ from those of our plant merely in being considerably smaller, and perhaps rather narrower in proportion.

It is to be observed, that although the appearances of fructification in all these three plants are clear and unequivocal, yet in the first two species at least, it is invariably the upper surface of the frond that is exhibited to our view; now, in all recent ferns, the fructification is situated on the under surface; we must therefore suppose that what we see in these specimens are not the masses of capsules themselves, but the impressions of them, as it were, stamped through the substance of the leaves by the pressure to which they were subjected in the process of fossilization. This appears to be most usually the case with those fossil ferns which occur in a fertile state, and may be one reason why it is more difficult to determine with precision the characters of the fructification in these than in the recent plants. Dr. Lindley long ago observed*, that fossil ferns are much more often found with their upper than with their lower surface exposed to view, the lower seeming to adhere more closely to the matrix; and Professor Göppert†, in his curious experiments

* Fossil Flora, text to t. 83.

† Syst. Filicum Fossilium, p. 293.

on the artificial production of vegetable impressions, found that plants of this tribe did, in fact, constantly remain attached to the substance in which they were imbedded, by their lower and not by their upper surface, especially if they were in fructification.

The carboniferous strata at Frostburg in Maryland, from which these fossils were procured, are described by Mr. Lyell* as being arranged geologically in a trough, and the shape of the successive beds has, he observes, been aptly compared to a great number of canoes placed one within another. The principal coal-seam is ten feet thick; the coal bituminous, though containing less of volatile matter than what is found farther west on the Ohio. There are numerous smaller seams of coal, under several of which Mr. Lyell found clays containing *Stigmaria*, "usually, as elsewhere, unaccompanied by other fossil plants;" but in one bed of clay, underlying a coal-seam, about fifty feet above the millstone grit on which the whole rests, he found leaves of two species of Pecopteris and an Asterophyllite, intermixed with abundance of Stigmariæ. Higher in the series, but still 300 feet below the principal coal-seam, occurred a bed of shale full of marine shells, some of which were identical with, and others had a near affinity to, species found in the British coal-measures†.

The fossil plants procured by Mr. Lyell at Frostburg, in addition to the three ferns already described, were the following:—

4. *Neuropteris cordata.*

(Very abundant, and certainly identical with the English plant. Very variable in size and in the proportional breadth of its pinnæ. These are sometimes oblique at the base, nearly as much so as in *N. acutifolia* of Brongniart, which is probably a variety of this species.)

5. *N. gigantea?*

(Doubtful; pinnules as closely placed as in *N. flexuosa*. It is intermediate in character between *N. flexuosa* and *N. gigantea.*)

6. *Cyclopteris?*
7. *Pecopteris arborescens.*
8. *P. abbreviata?*
9. *P.* —— (?).

(Perhaps a fragment of *P. gigantea* or *P. punctulata*, but too imperfect to be positively determined.)

10. *Lepidodendron tetragonum.*
11. *L. aculeatum.*
12. *Lepidodendron* ? ?

(Resembling in its markings the *Sigillaria Menardi* of Brongniart, and also the *Ulodendron minus* of Lindley and Hutton.)

13. *Sigillaria reniformis?*
14. *Stigmaria ficoides.*
15. *Asterophyllites foliosa.*
16. *A. tuberculata?*
17. *A. equisetiformis?*

* Travels in North America, vol. ii. p. 16–19.

† Lyell, *ibid.*

18. *Asterophyllites.*
(Undescribed, but said to be found in the "middle coal" near Manchester.)
19. *Artisia* —— ?
20. *Calamites nodosus.*
21. *C. dubius* ?

I am not aware that any of the three ferns which I have here particularly described, are marked by peculiarities calculated to throw any new light on the questions relating to the climate of the coal period. But the very striking similarity between the coal-plants of North America and those of Europe makes it probable that a similar kind of climate also existed in both countries at that æra; and whatever conclusions we may arrive at in relation to the carboniferous period in the one continent seem equally applicable to the other. Nothing that has yet been ascertained relative to the coal formations of either continent seems at all inconsistent with the suggestion of Mr. Lyell* touching the climate of the period in question. This view, which seems to me by far the most probable, is, that the climate was then characterized by excessive moisture, by a mild and steady temperature, and the entire absence of frost, but perhaps not by intense heat. I must admit, indeed, that our materials for the foundation of this theory are perhaps somewhat scanty, being chiefly the general character of luxuriance of the carboniferous vegetation, the great abundance of ferns, and the presence of large-leaved monocotyledonous plants of a tropical or subtropical aspect; for with regard to the Sigillariæ, Stigmariæ, Asterophyllites, Calamites, &c., their real affinities are, I think, too doubtful to allow us to found any arguments on them.

That extreme heat is not necessary to the existence of a very luxuriant and quasi-tropical vegetation, is sufficiently clear from Mr. Darwin's interesting observations on Chiloe and other islands of the southern temperate zone†. Chiloe, situated in the forty-second degree of south latitude, enjoying little summer heat, and subject to perpetual rains and mists, is covered, as he states, with forests of extraordinary density, and the luxuriance of the vegetation is such, that it reminded him of Brazil; large and elegant ferns, parasitical monocotyledonous plants, and arborescent grasses reaching to the height of thirty or forty feet, are abundant. Indeed, in the southern hemisphere generally, owing to the equable climate produced by the great proportional extent of sea, tropical forms both of vegetable and animal life range much farther from the equator than in our hemisphere. It appears very probable that the climate of the northern temperate zone, during the epoch in which the coal-measures were formed, may have been similar to that now existing in Chiloe and the adjacent parts of South America.

Still, considering that the principal coal-fields of England are situated from 13° to 15° farther north than that of Frostburg, of which I have here spoken, the close resemblance of their vegetation

* Travels in North America, vol. i. p. 148–9.
† Darwin's Journal, 2nd edit. p. 242, *et seq.*

is very striking. The absolute identity of some species is not perhaps so remarkable as the very great general similarity of the whole; for those among the Frostburg plants, which cannot be satisfactorily identified with British species, are in every instance very closely allied to them. We should not find so great a degree of resemblance on comparing the recent floras of two regions separated by so many degrees of latitude, whether in Europe or North America. If we may reason at all as to climate from the fossil vegetation of a country, we must suppose that the climate varied less rapidly with the latitude than it does at present.

I must not omit to take notice of the opinion maintained by Professor Lindley*, "That the numerical proportion of different families of plants found in a fossil state throws no light whatever upon the ancient climate of the earth, but depends entirely on the power which particular families may possess, by virtue of the organization of their cuticle, of resisting the action of the water wherein they floated previously to their being finally fixed in the rocks in which they are now found." To this conclusion it appears to me that there are strong objections. It seems to have been deduced by Professor Lindley from the results of an experiment (recorded in the third volume of the 'Fossil Flora') on the comparative durability of various plants when immersed in water. In the first place, as M. Adolphe Brongniart has already remarked, Dr. Lindley's theory does not at all explain why the proportional number of ferns should be greater in the coal formation than in any subsequent deposit, nor why the leaves of dicotyledonous plants, which are almost, if not entirely wanting in that formation, should be so abundant and so well-preserved in the freshwater deposits of the tertiary period. If maceration in water destroyed them in the one case, it would surely have done so in the other. Moreover, Dr. Lindley's experiment, however ingeniously devised and carefully conducted, does not supply all the data necessary for deciding the question; nor are its results altogether in accordance with the phænomena we observe in the carboniferous strata. The species of ferns submitted to experiment by him were only *six* in number†,—too few, I think, to justify us in concluding that the plants of that tribe generally possess in an eminent degree the power of resisting maceration in water. In this number were not included any of the more tender and delicate kinds of ferns, such as those *Hymenophylleæ*, which are almost comparable to mosses in the filmy, delicate and fragile texture of their leaves, and of which many representatives are found in a fossil state. It is difficult to believe, without more positive proof, that fronds so thin and membranous as those of several species of *Sphenopteris* which occur in the coal formation, could have endured long maceration in water, when we learn from Dr. Lindley's experiment that even that singularly hard and rigid plant the *Equisetum hyemale*, of which the stems are coated with silex, perishes within two years under this process.

Again, Dr. Lindley concluded from his experiment that the fruc-

* Fossil Flora, vol. iii. p. 12. † Ibid. p. 5.

tification of ferns was destroyed by long immersion in water; and he seems to consider this as an important corroboration of the justness of his views. He speaks* of "the very remarkable fact, that ferns are scarcely ever met with in fructification in a fossil state;" and if this were a fact, it would certainly be in accordance with the result of his experiment. But it is now known that the occurrence of the fructification of ferns in a fossil state is by no means so rare as that distinguished botanist supposed. It is shown in the present paper, that out of nine fossil ferns observed by Mr. Lyell at Frostburg, three were in a good state of fructification. And Göppert, in his 'Systema Filicum Fossilium,' figures and describes not less than twenty-five species in that condition, mostly from the coal-mines of Silesia.

Professor Lindley also found that branches of dicotyledonous trees, when soaked in water, lost their bark, and all external marks by which they might be recognised. But it is well known that the Sigillariæ (which Dr. Lindley himself considers as true Dicotyledons) are constantly found in the carboniferous strata with their bark and all its markings well-preserved.

These considerations seem to me to render it improbable, that the plants preserved in the rocks of the coal formation should have been subjected to maceration in water for a length of time before they became fossilized.

Another point which deserves some attention, in reference to the present question, is the compressed state in which the trunks of *Sigillaria*, *Lepidodendron*, and *Calamites*, are usually found in the strata accompanying the coal. This indicates that they must have undergone a very considerable degree of pressure previous to petrifaction, and while they were still in a comparatively soft and yielding state. The pressure which flattened these large stems, and which prevented the escape of the volatile ingredients of those accumulations of vegetable matter that formed the coal, would probably also prevent the decomposition of the other plants that accompanied them.

I think, therefore, there is reason to believe that the ferns and other plants which occur in the shales and sandstones accompanying the coal, were not subjected to the same conditions as the plants upon which Dr. Lindley made his observations. If they had, like those, been macerated in water for a great length of time, we could readily admit that a large proportion of the species might have perished. But if, as seems more probable, they were speedily buried beneath great accumulations of mud and detritus, then the conditions were essentially different from those of Dr. Lindley's experiment; and we have no right to infer from that experiment that whole tribes of dicotyledonous plants had perished, while the ferns which grew in company with them were preserved.

I have entered at some length into this question, because of the high authority which Prof. Lindley's name deservedly carries with it, and because I have observed that some of the most eminent geo-

* Fossil Flora, vol. iii. p. 3.

logists are disposed implicitly to adopt his conclusions, and to disregard altogether the evidence of fossil plants as to the former state of the earth's surface.

At the same time I readily admit, that the plants, of which we now find the remains imbedded in the carboniferous strata, may probably be but a very small proportion of those which at that time flourished on the earth. If, as seems to be now most generally believed, the coal-beds are derived from the vegetation of ancient swamps or lakes, existing in the very localities now occupied by such beds of coal, we could not expect to find in them the remains of other plants than such as grew in those bogs, or lakes, or swampy forests, or immediately around them, together perhaps with some which might be washed into them by occasional inundations. May there not have existed at the same time, in other parts of the world, (nay, perhaps, at no very great distance from the carboniferous regions,) great tracts of country, indeed whole continents, in which the local circumstances were unfavourable to the preservation of vegetable remains, and of which, consequently, the flora is totally lost to us? If, on the other hand, as some suppose, (and as may probably have been the case in some instances,) the coal was formed out of vegetable matter drifted down by rivers, and accumulated in estuaries or shallow bays, then it is clear that such deposits are not likely to include anything like a complete series of the vegetation of the then existing lands.

I think, therefore, that we ought to proceed with great caution in theorizing with respect to the vegetation and climate of the carboniferous æra. I do not admit that Professor Lindley's observations have destroyed the value of the evidence afforded by the great proportional number of ferns in the Flora of the coal-measures; I believe that that preponderance, together with the other characteristics of the fossil vegetation of that period, affords to a certain degree good evidence respecting the climate of those particular regions in which the coal-measures occur; but we should not be justified in extending our inferences farther. Those parts of Europe and North America in which the coal-fields were accumulated, may have existed at that time in the state of islands, like those of the present Pacific Ocean; but it would be rash to infer, as M. Adolphe Brongniart seems disposed to do, that no extensive continents at that time existed in any part of the globe. If, in all departments of geology, it is necessary to advance with caution, and to avoid dogmatism and rash generalizations, it is more especially necessary in the department of Fossil Botany, where so much of the evidence we possess is fragmentary and imperfect.

Additional Remarks on Pecopteris emarginata.

Since this paper was written, I have seen in the British Museum specimens of *Diplazites emarginatus*, Göpp., from Wettin near Halle. They are not in fructification, but exhibit the venation, and

especially the anastomosing of the lower veinlets, more distinctly than our American specimens. With these they agree so well, that I cannot but consider them as the same species; and therefore, although the specific name of *emarginatus* is certainly not applicable, I think myself obliged to retain it, to avoid the confusion arising from a multiplication of synonyms.

The *Pecopteris Göpperti* of Mr. Morris, from the Permian system of Russia, comes very near, in several respects, to *P. emarginata*; but the insertion of the pinnæ on the stalk appears to be different, and the veinlets are generally forked, whereas in our plant they are always simple.

DESCRIPTION OF THE PLATES.

Plate VI.

Figs. 1, 2, 3, *Pecopteris emarginata*, natural size.
4, 5, „ „ magnified.

Plate VII.

Figs. 1, 2, 3, *Pecopteris elliptica*, natural size.
4, „ „ barren pinnules magnified.
5, „ „ fertile pinnules magnified.

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2. *Notes on the* Wealden Strata *of the* Isle of Wight, *with an account of the Bones of* Iguanodons *and other Reptiles discovered at* Brook Point *and* Sandown Bay. By G. A. Mantell, Esq., LL.D., F.R.S. &c.

The author commenced with some remarks on the general geological structure and picturesque features of the Isle of Wight, and then proceeded to direct special attention to some extensive ledges of low rocks visible from a considerable distance, and occurring seaward of Brook Point, a low promontory near and to the east of Compton Bay. The face of the cliff is here formed by the bassetting edges of the Wealden clays and sands, which alternate with occasional layers of argillaceous shelly limestone, rolled blocks of which are strewed along the beach. This limestone is formed of the shells of *Paludina*, *Cyclas* and other Wealden species, and is in every respect identical with the Petworth marble and Ashburnham beds of Sussex.

The cliff at Brook Point is between thirty and forty feet high, and is capped by an alluvial bed of loam, sand and gravel. It is composed of beds of laminated clay and shale, with sands and sandstones of a bluish and reddish-gray colour, and these are interspersed with layers and isolated masses of lignite and lumps of iron pyrites.

East of the Point a chine or chasm occurs, from the summit of which a stream gushes out and dashes down the face of the cliff to

the sea-shore. This stream rises from beneath the sand beds inland, and flows through the alluvial gravel to the summit of the cliff.

The author then proceeded to quote a graphic description of this spot, written nearly thirty-five years ago by Mr. Webster*, and he referred also to the account given twenty years afterwards by Dr. Fitton†, who considers the compact variegated clay and sand appearing below the sand-rock of the Point as the lowest visible strata of the island. Both Mr. Webster and Dr. Fitton mention the great abundance of fossil wood at this spot, where there have been found many large trunks of petrified coniferous trees, of a dark brown colour. This petrified forest occurs in the variegated sand-rock above alluded to, and the stratigraphical features of the cliff containing it have therefore been long known. It appears that the projecting masses at the base of the cliff are the protruding edges of the sand-rock in which the fossil trees were imbedded, for this rock, from its greater hardness, resists the action of the waves long after the upper and less coherent strata have been washed away. The reefs seen at low water have in this way been formed.

Fossil Forest.—" The trees are lying confusedly one upon another. I saw no erect trunks, or any other indication that the forest had been submerged while growing in its native soil like that of the Isle of Portland; but, on the contrary, the appearance both of the trunks in the sand-rock, and of those exposed to view by the removal of the materials in which they were originally imbedded, is that presented by the rafts that float down great rivers, as for example the Ohio and Mississippi. Such rafts entangle in their course the remains of animals and plants that may happen to lie in the bed of the river, and at length subside and are buried in silt and sand. The fossil trees in this cliff are associated with large river shells and with the bones of colossal land reptiles. The fossil forest at Brook Point we may therefore consider as a raft of pines which floated down the river of the country near which the Wealden beds were deposited, and had become submerged in the delta or estuary at its mouth, burying with it the bones of reptiles and the large freshwater mussels it had entangled in its course.

" The trees when lying in the sandstone are invariably covered with their bark, which is now in the state of lignite, varying from one to three or four inches in thickness, according to the magnitude of the trunk. This carbonized cortical investment is quickly removed on exposure to the action of the waves, but the ligneous structure, the woody fibre, remains.

" The trees are calcareous and not siliceous like those of Portland. They are more or less traversed by pyrites, and the delicate veins and filaments of this mineral which permeate the woody fibre impart a beautiful appearance to the polished specimens, particularly to those which exhibit a transverse section of the stems. The trunks are generally of considerable magnitude, being from one to three

* Englefield's Picturesque Beauties of the Isle of Wight, p. 153.
† Geol. Trans., 2nd Ser., vol. iii. p. 202.

feet in diameter. I traced two upwards of twenty feet in length, and these were of such a size as to indicate a height of forty or fifty feet when entire. They appear to have attained maturity.

"In the conversion of the bark into lignite, and in the smooth condition of the trunks, this fossil forest presents a remarkable dissimilarity from that of the Isle of Portland, in which, so far as I have observed, the carbonized bark rarely, if ever, occurs, and the surface of the stems is similar to that exhibited by the trunks of old decorticated trees that have been much weathered by alternate exposure to air and moisture. At Brook Point, on the other hand, the trees appear to have been engulfed when fresh and vigorous, and when their bark and vessels were full of sap. The annular lines of growth are often very distinct, and I have traced from thirty to forty on some of the stems, but these circles are unequal, and indicate therefore a variation from year to year in the climate of the country in which they grew. The wood exhibits, under the microscope, coniferous structure of the type seen in the *Araucaria* (Norfolk Island Pine), the rows of glands or ducts being placed alternately, and the appearance being similar to that of the fossil wood of Willingdon in Sussex*. I observed no trace of the foliage of these trees, nor of their fruit, with the exception of a small cone, scarcely so large as that of the larch†.

"In the strata that overlie the fossil forest, thin interrupted seams and irregular masses of lignite are very abundant, and their substance is more or less impregnated with and permeated by iron pyrites. Fossils similar to these occur also in the clays of Tilgate Forest and at Hastings.

"The various conditions in which the remains of vegetables are preserved in the Wealden strata suggest many interesting inquiries. Why, for instance, is the bark so much more frequently carbonized than the woody fibre? Why do the trunks of Coniferæ occur in the state of coal in the old carboniferous strata and not in the deposits before us? What conditions occasioned the difference observable in the state of the fossil trees at Brook Point and at Portland? Why has the *Endogenites erosa* of the Wealden (a monocotyledonous tree) always a thick coat of lignite, while the *Clathraria* (a plant allied to the Yucca) is never carbonized? And lastly, is the interpretation of these phænomena to be sought for in the original organization of the plant, or in the state of the trees at the period of their submergence, or in the conditions of deposit, whether mineral or with reference to the degree by which they were affected by air and moisture?‡"

* Quart. Geol. Journ. vol. ii. p. 51; Medals of Creation, p.166, pl. 5. f. 3.

† Two cones (now in the possession of Mr. Dixon) have been obtained from the Isle of Wight, probably from the Wealden strata; but their locality being uncertain, no satisfactory evidence is afforded of their relation to the fossil trees under consideration.

‡ The author suggests that a white calcareous incrustation observed on many fossil bones obtained from this spot may probably be derived from the fresh-water springs that percolate through the strata of the cliff, which are composed of clay,

The strata at Brook Point continue for several hundred yards along the cliffs, and it was in these beds that the author discovered the large mussel-shells that inhabited the river of the country already alluded to. The *Unio valdensis* (as this species has been named) was first observed in the sandy clay beds immediately above the fossil forest, and several examples have since been found in other places along this line of cliffs. It is a species remarkable both for its large size and for the perfect state of preservation in which it is found. The horny ligament generally remains in a carbonized state, and the body of the animal occurs as molluskite, but the substance of the shell is often changed into compact calcareous spar, and nodules of crystallized sulphate of barytes of a pink colour are not uncommon within the shells*. From the same strata bones of the Iguanodon and other Wealden reptiles are obtained, the specimens usually collected having been washed out of the cliffs by the inroads of the sea, and being strewn along the shore. In this way they have commonly suffered so much by attrition that the processes are destroyed, and those parts defaced which are of most value to the anatomist as distinctive characters.

The number of bones collected along this coast during the last ten years amounts to many hundreds, and although from their rolled condition most of them are of no value as specimens, yet they serve at least to show the abundance of these relics. Many of them surpass in magnitude the largest of the Wealden bones in the British Museum.

The strata at Sandown Bay, shown in Dr. Fitton's section, emerge from under the greensands, and consist of clay, clay-shale, sand, and slabs of bluish-gray argillaceous limestone abounding in the usual shells of these freshwater deposits; and here, as at Brook, the bones of colossal reptiles are continually washed out of the cliffs. This shelly limestone, occurring in layers from one to three inches thick, and of uniform surface, is often employed for paving; slabs with the shells of the *Cyclas*, *Paludina* and *Unio* may often be detected in the pavements at Ryde and other places in the island, as at Battle, Hurstmonceaux and elsewhere in Sussex. The surface of the slabs is often deeply sculptured with ripple-marks; and very recently some markings have been observed that are supposed to be the imprints of the feet either of birds or reptiles.

Fossil remains of many of the large reptilian animals which have conferred so much celebrity on the strata of Tilgate Forest have been obtained from these contemporaneous deposits in the Isle of Wight, and amongst them the bones of the *Megalosaurus*, *Strepto-*

lignite, sulphuret of iron, and shelly limestone. The lignite he thinks might have supplied the carbonic acid, and he quotes the authority of Dr. Liebig in favour of this view.

* Doubt having been expressed as to the correctness of assigning a new specific name to this shell, the author states that Mr. James Sowerby, who figured and described the *Unio Martini* of Dr. Fitton (presumed by some to be the same species), concurs in his opinion, and has figured the shell under the above name for the 'Mineral Conchology.'

spondylus and *Iguanodon* are the most numerous. The author directs especial attention to a large thigh-bone together with portions of ribs and vertebræ (exhibited to the Meeting when this paper was read) which he obtained lately from the clay at the foot of the cliff near Brook. The thigh-bone is three feet four inches long ; it well exhibits the peculiar characters of the femur of the Iguanodon, namely, the head with its flattened lateral trochanter, the middle of the shaft with the mesial lateral process, and the inferior extremity with its double condyles separated by a deep sulcus or furrow both anteriorly and posteriorly. With this femur was found a tooth, fragments of ribs and other bones, and several vertebræ, caudal and dorsal. The tooth is large and worn down to a stump, and the fang has been absorbed owing to the pressure of a successional tooth. Like the femur it evidently belonged to an aged animal, and very probably to the same individual. The caudal vertebræ may also be assigned to the same reptile without hesitation, but the dorsal appears to be referable to the Cetiosaurus.

Another bone of Iguanodon to which the author directs particular attention is from Sandown Bay, the locality whence was obtained a large toe-bone, figured by Dr. Buckland in the Geological Transactions*. This specimen is the lower extremity of a tibia, or large bone of the leg, and its proportions are more colossal than those of any bone of this reptile hitherto described. The Sandown specimen exceeds by four times in linear dimensions the tibia of a young Iguanodon from Tilgate Forest one foot in length. It was therefore probably four feet long when entire; and from the relative proportion of the thigh-bone and leg-bone of the Iguanodon, as shown by specimens of the same individual in the British Museum, the femur of the limb to which this tibia belonged must have measured five feet, so that the entire length of the leg and thigh would be nine feet.

Besides these bones, the author has collected a fine metatarsal from the Wealden near Atherfield, as well as several very large and well-preserved vertebræ of the Streptospondylus, and fragments of the ribs of a large Iguanodon.

Section of the Wealden strata exposed by the cutting in the Tunbridge Wells Railway near Tunbridge.

"As connected with the subject of this paper, though situated in a district remote from the Isle of Wight, I add a few remarks on a section of the Wealden beds recently exposed, which is so interesting and so easily accessible, and may possibly be so soon obliterated, that a brief notice of it will be useful.

"This section has been formed by the cutting for the railway lately opened from Tunbridge to Tunbridge Wells, the line traversing Wealden strata along the whole distance. Immediately on leaving the Tunbridge station there is a deep cutting which exposes two bands, from three to four feet thick, of fawn-coloured sandstone re-

* Geol. Trans., 2nd Ser. vol. iii. pl. 41.

sembling that around Tunbridge Wells. Between these bands are beds of clay and laminated clay-shale, and seams of shelly argillaceous limestone of a bluish-gray colour. The usual shells of the Wealden and the remains of several species of *Cypris* abound in these strata, and the laminated character and general appearance of the clay beds and their fossils will remind the observer of the strata at Brook and Sandown Bay.

"These strata continue through the tunnel which then succeeds and for a considerable distance on the other side, and both in the sandstones and clays, stems of *Equisetum Lyelli* (a plant first discovered by me at Pounceford in Sussex) are abundant. They are invariably carbonized, and thin seams and blocks of lignite, evidently derived from accumulated masses of the same species, are thickly interspersed.

"Beyond the tunnel and after passing under a small bridge, blocks of marly sandstone may be observed containing remains of *Equisetum*, of *Cypris*, and of minute bivalves (*Cyclas parva* of Dr. Fitton). The surface of the shales and clays is often deeply rippled and covered with slight markings resembling worm-tracks, but these when freshly exposed have a carbonaceous coating indicative of their vegetable origin. The position of the strata in these Tunbridge sections is interesting, as it exhibits in a striking manner the undulated condition of the beds so commonly to be observed throughout the Wealds of Kent and Sussex,—a result of those earthquake waves, if we may so say, to which this region must have been long ago subjected.

"In the line that extends from Tunbridge to Maidstone, good sections of Wealden strata are exhibited in several places. At Wateringbury, as Mr. Bensted first pointed out, the clays and marls abound in *Paludinæ*, *Cyclades*, scales of fishes (*Hybodus*), &c.; and in some of the slabs of marlstone from this place, sent to me by Mr. Bensted, I found elytra of two or more species of Coleoptera, which are the only vestiges of insects I have obtained from the Wealden deposits of the south-east of England."

December 17, 1845.

John Morris, Esq., and Dr. Edward Kellaart were elected Fellows of this Society.

The following communications were read:—

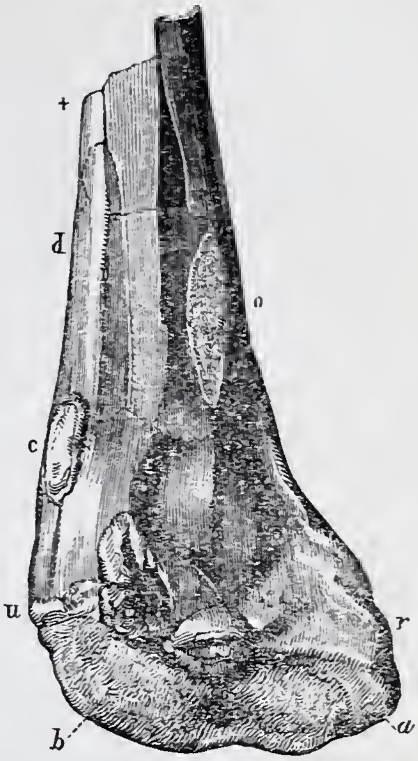
1. *On the supposed Fossil Bones of* Birds *from the* Wealden. By Prof. Owen, F.R.S., F.G.S. &c.

Having lately, in a re-examination of the Wealden fossil described in the Transactions of this Society*, chiefly on my authority, as the tarso-metatarsal bone of a Bird, exposed by the detachment of the

* 2nd Series, vol. v. p. 175. pl. 13. figs. 1*a*, 1*b*.

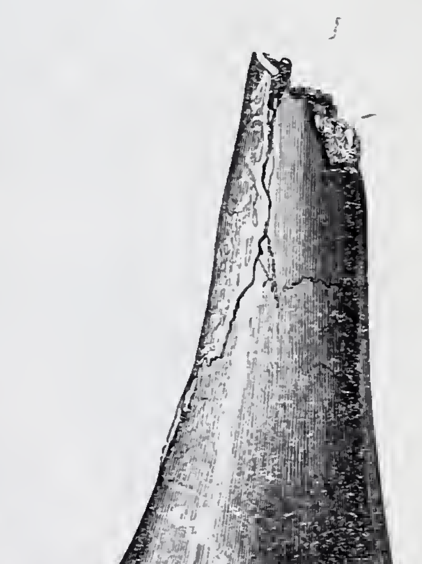
matrix that adhered to its extremity some characters not visible when the fossil was first submitted to me, and having been led by those new characters to institute a more extended and rigorous comparison of the fossil than it was in my power to do ten years ago, I believe myself in a condition to demonstrate my former error in ascribing it to the class of Birds, and I therefore lose no time in rectifying it. The character mainly relied on as proving the fossil in question to be the lower end of a tarso-metatarsal bone of a wading bird, was the rough oval spot marked *o* in fig. 1 *b*, pl. 13, of the above-cited volume, and this, if interpreted as the articular surface for the hind-toe, would indicate a form of metatarsal bone like that of the restored figure given by Dr. Mantell, by the dotted outline in the above-cited plate. But the characters since brought to light prove the bone (fig. 1) to have terminated much nearer the oval spot (*o*), since they consist of *two portions of the distal smooth articular* surface, one (*a*, fig. 1 & 3) situated near the margin of one side of the joint, at right angles to the axis of the bone; the other surface (*b*) being a smooth protuberance near the middle of the concave side, but at the end where the small mass of light-coloured matrix appears in Dr. Mantell's figure 1 *b*. Now, as these surfaces have formed part of the articular extremity of the fragment, and establish its true position, traces of the vertical or longitudinal fissures separating the condyles ought to be present, if the fossil were actually part of a tarso-metatarsal bone, and more especially on the convex side, fig. 2; for in none of the tarso-metatarsal bones of the numerous birds which have been compared with the fossil, are the grooves or foramina, indicative of the divisions of the end of the bone for the trochlear joints of the toes, entirely absent, as they are in the smooth, slightly undulating convex surface of the expanded end of the fossil.

Fig. 1.



Anterior or palmar aspect of the distal end of the humerus of a Pterodactyle. Wealden. (Natural size.)

Fig. 2.



Posterior or anconal aspect of the distal end of the humerus of a Pterodactyle. Wealden. (Natural size.)

On the metatarsal hypothesis, the prominent convex articular surface *b*, fig. 1, could be no other than part of the projecting trochlea for the middle toe; but it is uniformly convex, not grooved as in that trochlea in the Heron and other birds; and, moreover, there is no cleft in the fossil bone separating it from the adjoining condyle, which cleft must have been present if the fossil had been a tarso-metatarsal. There is a second smaller rough elliptical surface at *c* (fig. 1), on the concave side of the bone near the margin opposite to that where the larger surface *o* is situated: the median margin of the smaller surface *c* is slightly raised. This surface is wanting in the tarso-metatarsals of the Heron and other birds. But the most decisive evidence against the metatarsal character of the fossil in question, now that the true position of the distal articulation is determined, is given by the configuration of the opposite or convex side of the expanded end of the bone, which proves that end to have been simple, not trifid (fig. 2).

After the recognition of the above characters of the Wealden fossil, I proceeded to compare it with other bones of the skeleton of birds, and found in the lower or distal extremity of the humerus, the part that most nearly resembled the fossil in its present condition. This part presented, for example, the same unequal expansion, the same smooth and gently undulating convexity on the back part, and a similar concavity on the fore part; a portion of the distal articular surface corresponding with that marked *a*, and a prominence of the outer condyle, which corresponds with that marked *b* in fig. 1. In the humerus of most birds of flight, there is a rough surface on the concave (anterior) side of the distal end, about as far from the condyle or articular surface as the spot *o* in the Wealden fossil, and there is also, in some, as the Cranes and Herons, a small elliptical surface, lower down, near the opposite margin, with the edge next the middle of the bone slightly raised, like that marked *c* in fig. 1, but nearer the distal end.

I am led by these resemblances to regard the fossil as the distal end of a humerus, and by the analogy of that bone in Birds, to be part of the left humerus. The thin compact walls (figs. 4 and 7) and large cavity of the bone determine it to have belonged to a creature endowed with the power of flight. Yet, although the first bone of the wing in Birds offers the nearest general resemblance to the fossil, there are several important differences in the fossil.

The surface answering to *o* (fig. 1) is usually larger and of a

Fig. 3.

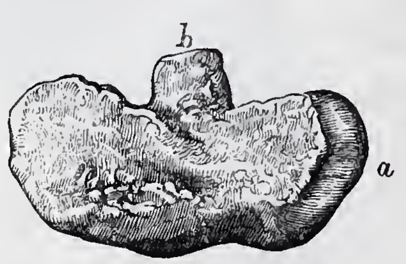


Fig. 4.

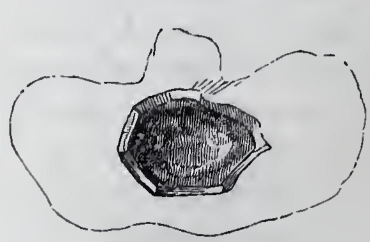


Fig. 3, under view, fig. 4, upper view, of the distal end of the humerus of a Pterodactyle. Wealden. (Natural size.)

rhomboidal form, as in the Eagle, or is triangular, as in the large Cranes, extending into the anterior concavity, and in all cases nearer to the smaller surface *c*, than in the fossil. The surface answering to *c*, also, is always lower down in the humerus of birds; in fact, on the fore-part of the ulnar condyle. The fossil humerus has the radial or outer condyle more produced, more extensive and thinner; the whole distal end expands more gradually, and to a greater extent in the fossil in proportion to the diameter of the shaft, *i.e.* than in any bird's humerus. If the surface *b* (fig. 1 & 3) be the anterior extremity of an oblique elliptic articular tuberosity, answering to the radial tuberosity in the bird's humerus, it is nearer the middle of the distal end of the bone, as it is in Bats and Pterodactyles; and the outer distal surface *a* is broader than the analogous surface, which rests on the radio-ulnar ligament in Birds.

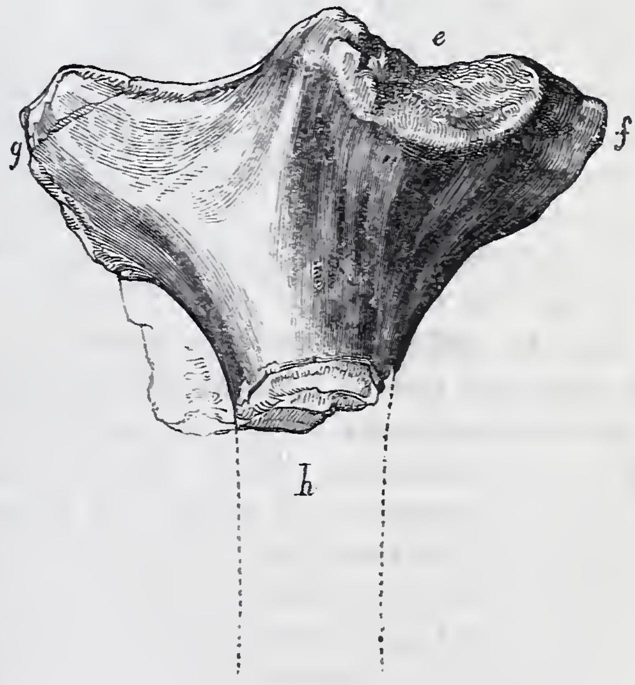
The linear ridges *d*, like those that afford attachment to the aponeurotic thecæ, which bind down the tendons as they glide along the metatarsus to the toes, in Birds, are not present on the fore-part of the humerus of Birds; but similar ridges are present on the back part of the upper half of that bone, and they exist in most of the long bones of Pterodactyles.

In short, the amount of resemblance and of difference respectively, which is demonstrable between the fossil and what I take to be the corresponding bone in Birds, is such as is found in certain bones of those bird-like reptiles the Pterodactyles.

The distal end of the humerus in the *Pterodactylus macronyx* from Lyme Regis, now in the British Museum, described and figured by Dr. Buckland in the 'Geological Transactions,' vol. iii. 2nd series, pl. 27, shows the same general form and gradual expansion; but the condition of the fossil does not permit the comparison to be pursued into the needful details for unequivocal determination. I proceed, therefore, to give the result of my re-examination of the second of the most characteristic fossils from the Wealden, attributed to a bird, that, viz., which I formerly stated in the note cited by Dr. Mantell to be "very like the head of the humerus of a bird, but to differ from any in the Museum of the College in the sudden expansion of the head*."

This expansion is due to the outward extension of the broad and thin process *g*, fig. 5, answering to the outer or deltoidal process in the

Fig. 5.



Posterior surface of the proximal end of the humerus of a Pterodactyle. Wealden. (Natural size.)

* *Loc. cit.* p. 176.

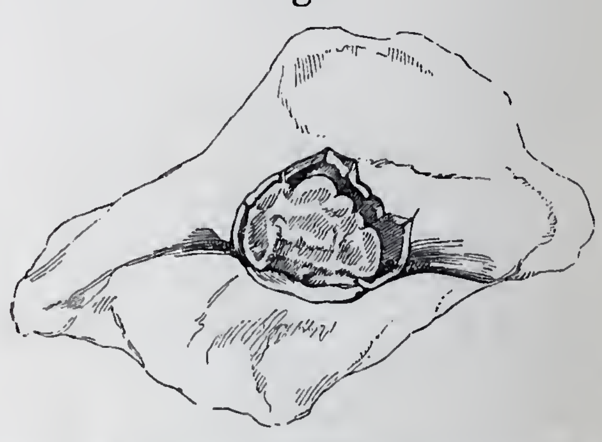
humerus of the bird, and to a corresponding production, though to a less extent, of the opposite or thicker angle *f*, answering to the inner tuberosity in Birds. The exposed surface of the fossil is therefore the posterior or *anconal* surface, towards which the transversely extended articular head of the bone *e* is inclined. The difference between the fossil proximal portion of the humerus and that part of the skeleton in birds of flight, is manifested by the more reniform figure of the head *e* in the fossil (figs. 5 and 6), its closer proximity to the inner tuberosity *f*, the minor production of that tuberosity, the absence of the cavity on its back part, and of the pneumatic foramen, which in birds of flight is there situated ; and lastly, the greater length and less extent in the direction of the axis of the bone, of the outer plate or process *g*.

Fig. 6.

Upper view of proximal end of the humerus of a Pterodactyle. Wealden. (Natural size.)

It may therefore be inferred, that the large cavity shown at the broken ends of the fossil (fig. 7) was filled, as in Bats and Pterodactyles, by a light fluid marrow, and not by air.

Fig. 7.



Lower view of proximal end of the humerus of a Pterodactyle. Wealden. (Natural size.)

The humerus of the *Pterodactylus macronyx* above cited shows a similar form of the outer proximal plate marked 1″*, and though this process is unluckily broken off in both humeri of that unique specimen, yet its great length is indicated by an impression in the matrix. The whole extent of this process is fortunately shown in the *Pterodactylus crassirostris* figured by Goldfuss†; and in that of the *P. longirostris*, given by Cuvier in the 5th volume of the 'Ossemens Fossiles,' pt. ii. pl. 23, Cuvier says, in reference to the humerus of the Pterodactyle, "On peut remarquer que sa tubérosité antérieure, (1) est fort saillante comme dans les tortues de mer et dans les oiseaux, ce qui convenoit trèsbien au premier os d'une véritable aile." (p. 369.)

The comparison is obviously general, in reference to the modification of the humerus in relation to flight; but the special difference of form and proportion between the process alluded to in the Pterodactyle and the homologous one in the bird, is precisely that which the fossil head of the humerus from the Wealden presents in comparison with the humerus of a bird of flight.

* *Loc. ante cit.* pl. 27.

† Beiträge zur Kenntniss verschiedener Reptilien der Vorwelt; Goldfuss, Nova Acta, &c., xv. pt. i. p. 63. tab. 7, 8, 9.

I conclude, therefore, that the Wealden fossil (fig. 3) is the proximal end of the left humerus of a Pterodactyle: and since the other fossil from the Tilgate strata (figs. 1 to 4) is the distal extremity of a left humerus, presenting the same degree of approximation to that part in the bird, but with differences irreconcileable with their identity, and which are most likely to be such as will be found in the same part in a Pterodactyle; and since the fossil (figs. 1 to 4) corresponds precisely in its proportions and the size of the shaft with the fossil (figs. 5 to 8), it is highly probable that it is part of the same bone; and it is more than probable that it has belonged to a Pterodactyle, and not to a bird: and thus it appears that an affirmative reply must be returned to the sagacious inquiry by Dr. Buckland, whether "the bones discovered in the strata of Tilgate forest may not, on more careful examination, prove to belong to the Pterodactyle*."

The Wealden fossils here commented on formed part of Dr. Mantell's valuable collection and are in the British Museum.

The species indicated by the highly interesting fossils, viz. the proximal and distal end of the humerus above described, must have been about one-third larger than the *Pterodactylus macronyx* from the lias of Lyme Regis, described by Dr. Buckland in the 3rd vol. of the 2nd Series of the Society's Transactions, p. 217; and it was probably as large as the Pterodactyle from the chalk exhibited by Mr. Bowerbank at a meeting of the Society in May last†.

This latter discovery has very naturally suggested a doubt respecting the described Ornitholites from the chalk, analogous to that expressed by Dr. Buckland with regard to the supposed Ornitholites from the Wealden, and the question may now be urged with greater force, since the re-examination of the supposed Wealden Ornitholites has tended to prove them to belong to the Pterodactyle. If only the shafts of hollow, long bones, like that figured in the Geological Transactions, 2nd Series, vol. vi. pl. 39. fig. 1, had been discovered in the chalk, the idea of their having belonged to Pterodactyles might be admissible; notwithstanding the prodigious size which, in that case, must have been attributed to the species of Volant Reptile of the cretaceous epoch; but the evidence of a bird in the chalk formation rests upon a much more characteristic bone, the distal trochlear end, *e.g.* of a tibia, a figure of which is given in the plate above-cited, fig. 2.

This form of the lower end of the tibia is quite peculiar to Birds, and relates to the equally peculiar absence of distinct tarsal bones; these bones being confluent with, and apparently forming, the simple superior extremity of the tarso-metatarsal bone in the bird. In the Pterodactyle there is a true tarsus, consisting of two larger ossicles in the first row, and of two or three in the second row, like those of Lizards, and the distal end of the tibia is modified conformably.

I have recompared the specimens originally submitted to me by the Earl of Enniskillen, and described as the remains of a longipennate bird in the Society's Transactions‡; and I cannot, at present,

* Geol. Trans. 2nd Series, vol. iii. p. 220.

† See *ante*, p. 7.

‡ 2nd Series, vol. vi. p. 411, and pl. xxxix.

see grounds for any other determination of those chalk fossils. If, as seems most probable, the Ornithichnites of the New Red Sandstones of Connecticut are the foot-prints of birds, species of the feathered class may well have been associated with Pterodactyles in the more recent secondary strata.

We have no satisfactory evidence, however, of the existence of birds in the Wealden.

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2. *On* Amber *and on the Organic Remains found in it.* By Professor Göppert of Breslau.

[Communicated by Sir R. I. Murchison, G.C.S.]

Amber appears to be a product formed during the period of the Molasse. The forests in which the trees grew whence this substance was derived, were situated in the south-eastern part of what is now the bed of the Baltic, in about 55° north latitude, and 37°–38° east longitude. With the commencement of the diluvial period this forest was gradually (probably at long intervals) destroyed, being swept away by diluvial torrents, and possibly also by storms coming from the north and north-east, and the amber was thus drifted to the south and south-west, on the coasts and in the countries where we now find it. Amber was a resinous exudation from an extinct pine, *Pinites succinifer*, most nearly allied to *Pinus abies* and *P. Picea,* but differing from these in several respects. The resin exuded chiefly from the root stock, but also from the bark and the wood, as is still the case with the resin called *Copal*, and others. The different colours of amber are derived from local circumstances of chemical admixture.

Among the fragments of vegetable matter contained in this substance those of dicotyledonous trees are chiefly abundant, and the tribe of *Coniferæ* no doubt occupied a great part of the amber forest. Of Pine there are at least four species, and with these we find *Cypress*, *Taxodium*, *Thuia* (five species), and also *Juniper* and *Ephedra*. Of leaf-bearing trees we find *Quercus*, *Fagus*, *Carpinus*, *Betula* and *Populus*; and of underwood, *Ericaceæ* with coriaceous leaves, &c., forming in the whole a flora comprising forty-eight species, which has considerable resemblance to that of North America. There was also a cryptogamous flora, including a beautiful fern, *Pecopteris Humboldtiana*, several mosses, and some small *fungi*, *Confervæ* and liverworts which are yet undetermined.

The fauna of this period was extremely numerous, upwards of 800 species of insects having been discovered, besides the remains of *Crustacea*, *Myriapoda*, *Arachnidea*, &c. The insects include *Aptera*, *Diptera*, *Neuroptera*, *Coleoptera*, *Libellulæ*, &c., but water insects are rare. Only a few hairs and feathers of Mammalia and Birds have as yet been obtained, and the fragments of Amphibia and Fishes that have been described are artificial productions.

All the remains, both of vegetables and animals, contained in the

amber exhibit only a generic identity with existing plants and animals, and are not specifically the same. The most nearly allied forms occur sometimes in the same district, but more frequently in North America. Several of the species exhibit, however, no analogies with known forms.

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3. *Notice of an Earthquake and a probable Subsidence of the Land in the district of* CUTCH, *near the mouth of the* KOREE, *or Eastern branch of the* INDUS, *in June* 1845. Extracted from a Letter to Capt. NELSON, R.E.

[Communicated by the President.]

"ONE of Capt. McMurdo's guides was travelling on foot to him from Bhooj. The day he reached Luckput there were shocks of an earthquake, which shook down part of the walls of the fort, and some lives were lost. At the same time as the shock the sea rolled up the Koree (the eastern) mouth of the Indus, overflowing the country as far westward as the Goongra river (a distance of twenty English miles), northward as far as a little north of Veyre (forty miles from the mouth of the Koree), and eastward to the Sindree Lake. The guide was detained six days (from June 19th to 25th), during which time sixty-six shocks were counted. He then got across to Kotree, of which only a few small buildings on a bit of rising ground remain. Most of the habitations throughout the district must have been swept away, the best houses in Scinde being built of sun-dried bricks, and whole villages consisting only of huts made of a few crooked poles and reed mats. The guide travelled twenty miles through water on a camel, the water up to the beast's body. Of Lak nothing was above water but a Fakeer's pole (the flagstaff always erected by the tomb of some holy man); and of Veyre and other villages only the remains of a few houses were to be seen.

"There are said to be generally two earthquakes every year at Luckput. The Sindree Lake has of late years become a salt marsh."

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4. *On the Occurrence of Nodules (called Petrified Potatoes) found on the Shores of* LOUGH NEAGH *in Ireland.* By the Very Rev. Dr. BUCKLAND, F.R.S. &c. &c., Dean of Westminster.

THE author stated that these peculiar nodules seem to be limited in their occurrence to the space between high and low water on the margin of Lough Neagh. Their average size is from two to three inches in diameter; they are irregularly spherical or suboval, with the surface occasionally indented. They are composed of a grey marlstone interspersed with black and green sand. They effervesce with acids.

Extraneous fragments occasionally project from them and are half imbedded in their sides. On being broken they are found to be intersected with cracks, like septaria, probably the result of desiccation, and subsequently filled by crystalline carbonate of lime.

The author explains the origin of these stones by referring to the analogous concretions of clay described by him many years ago, and occurring on the sea-shore at Lyme Regis. These latter are coprolitic, containing within them undigested scales and bones of fishes; but the Lough Neagh stones, although only containing fragments of stone, are, like these marine Bezoars of Lyme, formed by the rolling action of the waves of the lake on balls of clay, which gather up any extraneous substance that may come within their adhesive contact.

They have been subsequently hardened by exposure to the drying action of sun and wind in summer, and afterwards have again undergone attrition by the waves when the waters of the lake have once more reached them, perhaps at the return of winter.

January 7, 1846.

Henry Scale, Esq., and George Thornton, Esq., were elected Fellows of the Society.

The following communications were read:—

1. *On the Fossil Remains of* Birds *in the* Wealden *Strata of the* South-east *of* England. By G. A. Mantell, Esq., LL.D., F.R.S.

As the recent communication of Professor Owen, "on the Supposed Fossil Bones of Birds in the Wealden,"* relates to a specimen described by me in the Geological Transactions, vol. v. p. 175, and accurately figured in that volume (pl. 13. figs. 1 and 3), I am inclined to solicit the attention of the Society to the following remarks on this interesting subject.

These two portions of bone were discovered by me twelve years since in a quarry near Cuckfield in Sussex. Each specimen was imbedded in a mass of sandstone of the same colour and composition; and though formed separately, and the intermediate portions both of bone and sandstone wanting, the resemblance between the fossils was such that I did not hesitate to consider them as the upper and lower extremity of the same bone. I cleared away the stone with great care, and attached the two portions to a card, with a dotted outline to indicate the supposed line of union. The specimen was exhibited in this state in my museum at Brighton; the humerus of a bird being placed beside it, to show the general resemblance

* See *ante*, p. 96.

between it and the fossil. When Professor Owen, in 1835, obligingly offered to institute a rigorous examination of all the bones in my collection that were supposed to be referable to Birds or Pterodactyles, his attention was particularly requested to the specimen in question. The result of that examination was given by me in the Memoir on Fossil Birds, above referred to, and to that paper I beg to refer, to avoid unnecessary repetition. It will suffice for my present purpose to state that Professor Owen deemed my conjecture as to the original individuality of the two portions erroneous, and referred the head of the bone to a humerus, as I had done, but the other extremity he pronounced to be the tarso-metatarsal of a Wader. In Professor Owen's recent communication to the Society, the data on which his present interpretation of that fragment is founded are fairly and perspicuously detailed. Both portions he now admits to belong to but one bone; and the supposed tarso-metatarsal, which upon such high authority I had announced as affording proof of the existence of birds during the Wealden period, proves to be the lower extremity of a humerus. This humerus, for anatomical reasons which are fully explained in Professor Owen's communication, he now considers to be indisputably that of a Pterodactyle, and not of a Bird; and he also arrives at the conclusion that all the other supposed birds' bones of the Wealden must be referred to flying reptiles; an opinion which I submit is not based on satisfactory grounds. In the first place, the bone which has given rise to these remarks is imperfect at both extremities. The inferior end, though now rendered somewhat more intelligible from a few particles of stone having recently been removed, has but a very small part of the articulating surface remaining, and there are no characters by which a correct outline of the original could be restored. The upper part is also imperfect, and if it be assumed to belong to a Pterodactyle, it should, I conceive, have some indications of the prominent convex head (*a*) to fit the socket of the glenoid cavity, as in the humerus of the *Pterodactylus crassirostris* of Goldfuss, of which an outline is annexed; but no vestige of such a process can be discovered. The utmost therefore that can be predicated as to the fossil is, that it is the humerus of an animal capable of flight; that it possesses characters which bring it in close relation to the corresponding bone of Birds and Pterodactyles, but that the state of the articulating surfaces of the extremities is too imperfect to warrant a positive determination as to which order of beings the original belonged. To affirm that this humerus is that of a Pterodactyle appears therefore to me, in the present state of our knowledge, just as likely to lead to error as was the former misinterpretation of the lower extremity of this fossil. In the next place, notwithstanding the accession which has been made to palæ-

Humerus of Pterodactyle from Goldfuss.

ontology since the lamented death of Baron Cuvier, the opinions of that illustrious philosopher on this subject ought not to be rejected upon such insufficient data as those hitherto obtained. Some of the specimens inspected by Baron Cuvier are not at this time exhibited in the British Museum, nor have I been able to obtain a sight of them to examine them anew; the humerus was not found till after the death of Baron Cuvier. The whole of the evidence which satisfied the founder of Palæontology of the existence of birds' bones in the Wealden strata is therefore not before us: but be this as it may, I contend that it is premature and unphilosophical to pronounce that all the bones belonging to animals capable of flight found in these deposits are to be referred to Pterodactyles; the evidence may be deemed presumptive but not conclusive: surely the great discrepancy between the former and present interpretation of the fossil that has given rise to these observations affords a salutary caution which should not be wholly disregarded.

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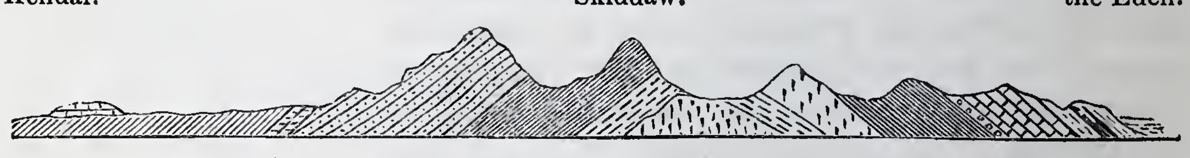
2. *On the Classification of the Fossiliferous Slates of* Cumberland, Westmoreland *and* Lancashire (being a Supplement to a paper read to the Society, March 12, 1845). By the Rev. A. Sedgwick, M.A., F.R.S., Vice-Pres. G.S., Woodwardian Professor of Geology in the University of Cambridge.

Part I.

§ 1. *Introduction.*—An abstract of my former memoir on this subject having been published in the first volume of the Geological Journal*, I am spared the necessity of entering on many details by way of introduction. Since however the subject before me is one of great complexity, I may be permitted to enumerate the results I before arrived at, and to illustrate them by sections.

The general section through the great Cumbrian cluster of mountains gives us three distinct groups of slate rocks.

1. General Section across Cumberland.



11. New red sandstone.
10. Coal-measures.
9. Mountain limestone.
8. Old red sandstone.
7. Coarse slate and flagstone.
6. Calcareous slate of Coniston.
5. Green roofing slate and porphyry.
4. Skiddaw slate.
3. Chiastolite slate.
2. Syenite.
1. Granite.

* Vol. i. p. 442.

III. Upper system of slates, with a few calcareous bands full of fossils, the whole deposit more or less fossiliferous.

II. Green roofing slate and contemporaneous porphyry, &c.

I. Skiddaw slate, the lower part of which is metamorphic.

The superficial extent of these three groups is represented on the maps of Cumberland and Westmoreland which I have had the honour to present to the Society, and the lowermost (I.) has no exact parallel in Wales. The one marked II. is put on the parallel of the Snowdonian slates, but in Cumbria contains no fossils. The next (III.) commences with beds of the age of the Caradoc sandstone, and ends with rocks obviously of the age of the Upper Ludlow rocks and tilestone of the Silurian system: it therefore includes the whole or nearly the whole of that system. The subdivisions of this great physical group (III.) were described in detail in the paper just alluded to, and were in the following order:—

6. A great group nearly parallel with the Upper Ludlow rock, and ending on the banks of the Lune with a red flag or tilestone.

5. Coarse slates, flags, grits, &c.

4. Ireleth slates, &c., subdivided into three subordinate groups: viz.

- γ. Upper Ireleth slate.
- β. Calcareous slate and limestone.
- α. Lower Ireleth slate.

3. Coniston or Furness grits. Thickness greater than No. 2.

2. Coniston or Brathay flagstone. Thickness 1500 feet. On the parallel of Wenlock shale.

1. Coniston limestone, surmounted by calcareous shales and slate. Aggregate thickness about 300 feet. Fossils, Lower Silurian.

During the past summer I have re-examined a part of the evidence on which I endeavoured to establish these subdivisions of the fossiliferous slates of Westmoreland, &c., and I still adopt the first four subdivisions almost without change. But No. 5. (coarse slates, flags, grits, &c.) I now consider as forming a sub-group of No. 4, or Ireleth slates, and No. 6. I subdivide into two groups,—a lower and an upper. The lower of these two groups passes into the system of the Ireleth slates in the descending sections, and in the ascending sections passes into the upper group, which ends with the tilestone. This slight change I was compelled to adopt when I endeavoured to lay down the subdivisions of the whole fossiliferous series on the county map; but it is in itself unimportant, and it involves no change of principle. According to this scheme, No. 5, the upper group (on the parallel of the Upper Ludlow rock) is subdivided into—

- *b*. Arenaceous slates, grits and flags, almost without cleavage, and passing in ascending order into green and red arenaceous flagstone (*tilestone*) (*c*.).
- *a*. Slates, grits and flags, with partial slaty cleavage, and passing into and blending with δ of No. 4.

No. 4. Ireleth slates, &c., includes

- δ. Coarse slates, flags and grits, &c.
- γ. Upper Ireleth slates.

β. Calcareous slate and limestone.
α. Lower Ireleth slates.

These are followed by No. 3, the Coniston grits, No. 2, the Coniston flagstone, and No. 1, the Coniston limestone, &c.

The scheme here given agrees with the annexed ideal vertical section of the whole Cumbrian series, inferior to the old red sandstone.

IV.	7 Great scar limestone.		
	6. Old red sandstone.		
III.	5. Upper slate of Kendal.	c.	Red flagstone.
		b.	Coarse flagstone.
		a.	Finer flagstone.
	4. Ireleth slates.	δ.	Coarse slates, flags and grits, &c.
		γ.	Upper Ireleth slates.
		β.	Calcareous slate and limestone.
		α.	Lower Ireleth slates.
	3. Coniston grit.		
	2. Coniston flags.		
	1. Coniston limestone.		
II.	Green slate and porphyry.		
I.	Skiddaw slate, the lower part metamorphic.		
	GRANITE.		

Note.—The letters and figures of reference in this table apply to the different sections accompanying the present paper.

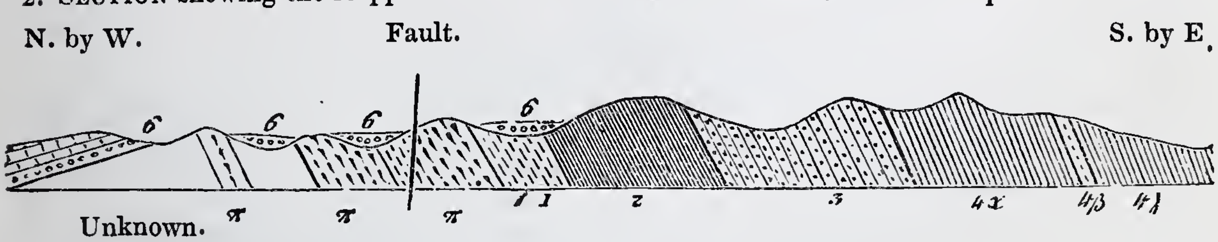
In the following communication it is my object, first, to explain the scheme above given by an appeal to actual sections and lists of fossils; and secondly, by help of this scheme to explain the physical structure and geological relations of a remarkable tract of country, including Howgill Fells, the Fells near the foot of the valley of Dent, and Middleton Fells, which range to the neighbourhood of Kirkby Lonsdale. The latter portion of my task is by far the most important, as it relates to a country with the structure of which I was almost entirely unacquainted before last summer, and which had never before been examined in any detail.

§ 2. *Successive groups.—The fossiliferous series.—Evidence offered by detailed sections, &c.*

1. *Coniston limestone and calcareous slate, &c.*—The general relations, structure and fossils of this group have already been given in some detail; and I should not here attempt to add anything on this head to the published abstract, had I not, during the last summer, visited the north-eastern extremity of the formation near Shap Wells, and the other extremity at the south-western end of Cumberland. At both localities there are phænomena which deserve a passing notice. Near Shap Wells the Coniston limestone is in an indurated, concretionary and altered form, and is repeated twice over in the brook which runs past the wells; while an overlying mass of old red sandstone and a mass of felspar rock occupy the interval (about two or three hundred yards) between the two masses of limestone.

I formerly explained these appearances by supposing that the altered structure of the limestone or calcareous slate was due to the porphyry and felspar rock, which had burst in upon the line of the limestone and separated it into two masses. New cuttings for a railroad through this part of the country have given me what I think a better view of its structure. I now think the porphyry (like the porphyry found in some places immediately under the range of the limestone) is of an older date, and that the double appearance of the limestone is due to a fault. The accompanying section will sufficiently explain my meaning.

2. SECTION showing the reappearance of the CONISTON LIMESTONE in consequence of a fault.



The phænomena are of great interest, but my limits prevent me from giving more than this passing notice of them; and it is obvious that they involve no principle of classification affecting the fossiliferous slates. Before I quit this subject I may just remark, that where the granite rises through the porphyry there are beautiful and complicated mineral results. Both the porphyry and granite are changed, but the demarcation may be pretty nearly traced, as the main masses are not confounded. About a mile north of Shap Wells the granite appears to have cut off the limestone. It is surmounted by a micaceous glimmering slate (like that so commonly seen close to the granite of Devonshire and Cornwall), which in one place is riddled through by granite veins*. Farther on the ascending section these granular and micaceous slates appear to pass into a hard splintery rock (in some places approaching the character of a felstone slate) of great thickness. These hard slates are only the Coniston flags (No. 2) altered by the granite, and, as is well known, they are traversed by one or two dykes of red quartziferous porphyry of a later date. In the long range of the Coniston limestone, from Shap Wells to the banks of the Duddon, which forms the boundary of the south-west end of Cumberland, I have at present nothing to add to statements given both in former papers of our Transactions and in the abstract in the first volume of the Geological Journal †, to which I must refer. But I was anxious to visit the south-west end of Cumberland, in the hope of deciding three questions. The first is, whether the Greystone House limestone on the hills west of Duddon Bridge is a true Coniston limestone? This bed is underlaid by beds of schaalstein, porphyry, slate, &c.; and

* I believe also that the granite has pushed the upper rocks out of their bearing, so that they are now seen to the south of the line of strike indicated by the same rocks farther south-west.

† *ante cit.* page 442.

similar rocks overlie the Greystone House limestone as far as the borders of the estuary immediately below Duddon Bridge. This fact is indicated in the colours of my field map exactly as I finished this part of it in 1822. My examination during the past summer enables me to answer this question in the affirmative. The limestone, though granular and crystalline, passes into ferruginous, cellular, calcareous slabs with fossils; and the whole development of the group (with the exception of a partial mineral change caused by the association with igneous rocks) is exactly like that of the Coniston limestone, and is very nearly on its line of strike, only a slight deviation having been produced by the valley of the Duddon. These alternations of fossiliferous and igneous rocks are anomalous in this part of England; but the very anomaly brings the formation I am describing into more intimate comparison with the rocks of the same, or nearly the same age in North Wales. Assuming the truth of what has been stated, it follows that the limestone must have been shifted by a vast fault and break of the whole series of strata, more than two miles from its original strike. Those who have studied the great dislocations of the strata near Coniston Waterhead will have little difficulty in admitting what is here stated*.

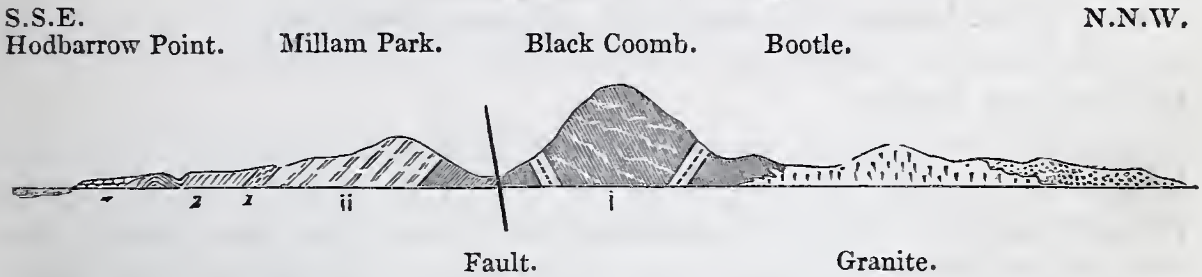
The second question I wished to examine was this,—Is there in the structure of the neighbouring county anything to explain this enormous Greystone House fault? I have already in another place answered this question in the affirmative. Immediately to the west of Greystone House, the rugged hills of green slate and porphyry rise to an elevation of about 1500 feet, and are penetrated by dykes of quartziferous porphyry (π). Similar slates and porphyries are continued farther south at a much lower level, and their beds are shattered in many directions: they then form the well-defined ridge of Millam Park, and range towards the sea along that ridge with a more regular strike, and a dip towards the south-east. Commencing among the shattered masses of slate and porphyry above noticed, and on the west side of the Greystone House fault (which runs nearly north and south), there runs a second enormous fault south-east and north-west down the Whitchamp valley as far as the sea-coast. On the north side of this second fault rises the contorted Skiddaw slate of Black Coomb †, which contains mineral veins (with lead, cobalt, &c.), is pierced by dykes of quartziferous porphyry, and at its northern end is altered by and jammed against the granite of Bootle. Close to the junction the altered Skiddaw slate is pierced with fine veins of true granite, rivalling some of the corresponding phænomena of Cornwall. The upheaval of the system of Black Coomb produced therefore, first, the great Whitchamp fault; and secondly, not being powerful enough to break through the superincumbent slates and porphyries farther to the north-east, shattered a portion of them to

* This enormous fault, produced by an upcast to the south, has been described in my former papers, and is laid down on the coloured county map in the possession of the Geological Society.

† See the annexed diagram, in which the rocks intersecting the slates (i) are of this porphyry.

fragmentary masses, and then tore the whole system of Millam Park bodily from the other rocks of the same age, and carried them full two miles to the south-east of their original strike; thus producing the second or Greystone House fault, which is marked on the surface by the sudden great shift of the Coniston limestone, as indicated in the previous description. My present limits preclude any further details, but the accompanying section will I trust make this short description intelligible.

3. Section across Black Coomb.



The third question I was anxious to solve was this,—Is the Coniston limestone continuous, so as only to disappear (along with all the other rocks) under the drifted matter which fringes the south-west coast of Cumberland? Or is it degenerate, appearing only here and there, in discontinuous concretionary masses, before it is finally cut off near the coast? Judging only by my remembrance of what I saw in 1822, and by the colours laid on my map at that time, I should have said that the Coniston limestone was continuous, and that so far from being degenerate at its south-western extremity near the coast of Cumberland, it was much thicker there than in any other part of its range from thence to Shap Wells. From the marshes south-east of Wander Hill to the pastures south-west of Beck Farm (a distance of full two miles), the Coniston limestone group is magnificently developed, having an aggregate thickness more than double that of the same group (including the overlying calcareous slate) in its range through Westmoreland and a part of Lancashire. There is a great open quarry behind Beck Farm, in thick beds of nearly vertical black limestone with white veins. They form the base of the series, and counting from them to the highest calcareous beds with bands and concretions of limestone, we have a thickness of full 600 feet. Under this limestone is a fine schaalstein passing into porphyry; its beds are perfectly parallel to the limestone, and for some depth below it contain the well-known Coniston fossils. I think this fact of importance, as it shows the uninterrupted continuity of the porphyritic and overlying system. At Water Blain the limestone is cut through by a fault, marked a narrow marshy valley, beyond which the limestone is contorted and traversed by thick veins of red oxide of iron. In another quarry the limestone rests on schaalstein, and is partially altered and penetrated near its base by flakes of serpentine.

Before I quit this discussion on the Coniston limestone, I may be permitted to recall attention to the ridge of High Haume (south of

Dalton), on the other side of the estuary of the Duddon. The rocks are there in a vertical position; and, crossing from the shore of the Duddon estuary towards Dalton, we have the following sequence:—

(1.) Sharp ridges of porphyry and schaalstein (exactly like those under the Coniston limestone).

(2.) Beds of dolomite, broken and shattered, with *Favosites fibrosa* (but fossils extremely rare).

(3.) Calcareous slate, with many fossils of the Coniston limestone.

(4.) Thin bands of schaalstein, slate and porphyry.

(5.) Obscure bands of vertical slate, ill-exposed, and with no well-defined fossils.

Taking the mineral structure and fossils into account, I had no hesitation, during my preceding visit in 1844, to class a part of this calcareous mass with the Coniston limestone. From the great thickness of the shattered dolomitized limestone, I was disposed to think it probably a mass of mountain limestone (for that formation is close at hand) entangled among the porphyries. I now feel assured that it is only an altered form of Coniston limestone, and its thickness is perhaps not greater than that of the same limestone on the Cumberland side of the Duddon estuary. Let it be borne in mind that there is the enormous dislocation already alluded to, and that we have in this very district the indications of great but anomalous eruptions of contemporaneous porphyry both immediately before and after the formation of the Coniston limestone, and all difficulty will, I think, vanish. With the exception of the dislocated mass above described, there are no Lower Silurian rocks to the south of Duddon Bridge. The statements in the abstract of my former paper amply define the general age of the Coniston limestone, and enable us to class it with the highest portions of Caradoc sandstone.

2. *Coniston flags.*—Respecting this group I have not many details to add to those of my former paper. It forms the true base of the Upper Silurian rock of this part of England. I have now traced it through parts of the valleys of Dent, Sedbergh, and Ravenstone Dale, on the eastern skirts of the fossiliferous slates, and in several places it contains *Cardiola interrupta*, along with the Upper Silurian fossils (*Graptolites ludensis*, &c.), mentioned in the abstract of my paper of last March. There can therefore be no doubt about its true place in the series. Among the highest beds of this group on the road between Hawkshead and Coniston are *Orthoceratites subundulatus*, Portlock, and another species not yet described.

3. *Coniston grit.*—The beds of this group, consisting of hard grits, &c., have a remarkably uniform character, considered as a whole,—only at their northern end they are degenerate so as to give a less impress to the features of the country. They reappear in the great undulations of Howgill Fells and Middleton Fells, &c. Throughout they show a remarkable association with spherical concretions often more or less calcareous, in which respect they offer analogies with many of the harder Upper Silurian grits of North

Wales*. Fossils are extremely rare in this group; but, after a careful search, some have been discovered. Among these are *Cardiola interrupta*, *Graptolites ludensis*, and fragments of Trilobites. To which may be added, *Orthoceratites Ibex*, and *O. subundulatus* of Casterton Low Fell which belongs to this group.

4. *Ireleth Slates, &c.*—These beds are thus subdivided:—

δ. Coarse slate and flags, &c.
γ. Upper or great Ireleth slates.
β. Upper limestone.
α. Lower Ireleth slate.

To enter on any elaborate description of this most complicated group would involve me in almost endless details, and I must content myself with little more than an enumeration of leading points, and refer to sections.

4 α, or *Lower Slates*, occupies a band of very highly inclined beds more than half a mile broad, between the upper limestone of Tottlebank Fell and the zone of the Coniston grits. Under the line of the same upper limestone (β) there is at least an equal thickness of slaty beds in the Ireleth country, on the south side of the Duddon estuary. I refer the slates of Bannisdale Head and Bretherdale to this sub-group. In general mineral structure it is almost identical with the group (δ) of higher slates, and there is indeed no definable difference. I know of no fossils in this group in the Ireleth country except *Graptolites ludensis*; but, from the general absence of quarries, they may exist and yet have escaped notice.

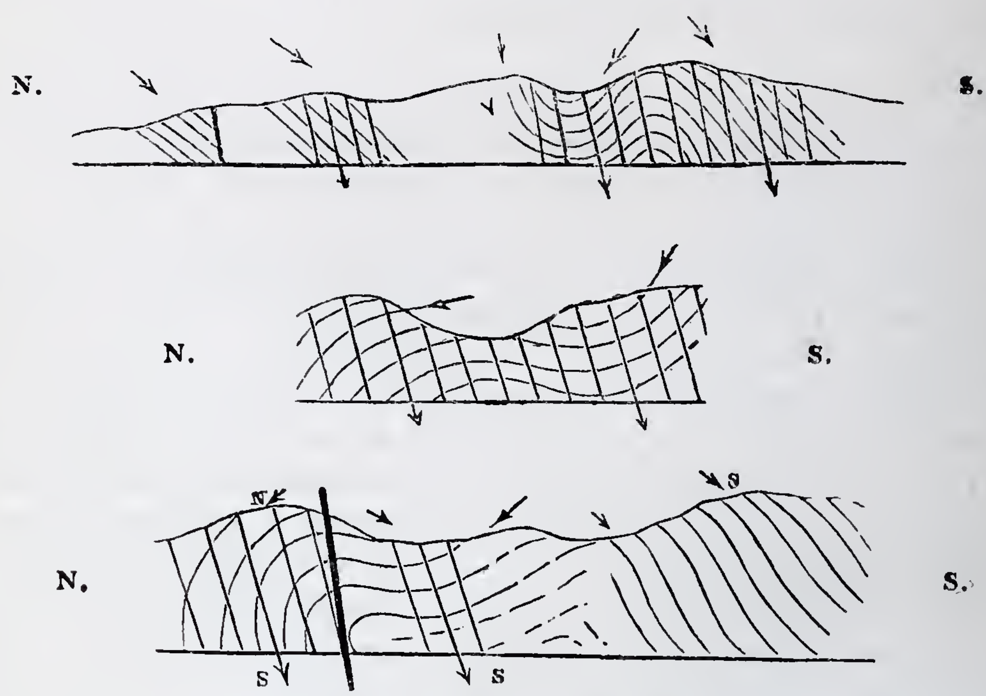
4 β, or *Upper Limestone.*—This limestone appears in five places on the south-east side of the Duddon Sands. In this part of the range it is of considerable thickness, and is still worked at Meer Beck in a fine open quarry †. Most of the old quarries are deserted, as good mountain limestone is found by the sea-side close at hand, for economical use. Farther towards the north the band appears to thin out; but it re-appears on the south face of Tottlebank Fell, in the places indicated in my former paper. It is there very degenerate. The limestone is shelly, but extremely impure. It is composed of irregular discontinuous concretions, and it dies away on its line of strike before it reaches Coniston Lake, and is not seen again, in any appreciable form, farther towards the north-east. Fossiliferous bands (with *Terebratula navicula*, &c.) do however break out farther to the north-east, nearly on the strike of this limestone, *e. g.* on the right side of the road from Windermere Ferry to Hawkshead.

* These balls, both in the grits and slaty bands, are of various sizes,—sometimes true septaria, sometimes filled with earthy ferruginous rotten-stone. They follow the beds and not the cleavage planes, and among the more slaty masses they are spheroidal, with their longer axes in the direction of the beds. On the contrary, in the Millam quarries, the calcareous concretions of the Coniston limestone are formed on the cleavage planes, and not on the beds.

† In one quarry there occur numerous specimens of a square-stemmed Encrinite (*Tetracrinites* ?).

4 γ. The great Ireleth slate quarries were noticed in my former paper. The whole hill, in which these quarries are very largely worked, is thrown into most complicated contortions. But through all these complicated curves the planes of slaty cleavage pass continuously, and almost without any deviation in their strike and dip. I hope to return to the description again, in a paper devoted to the examination of the phænomena of slaty cleavage. But I subjoin several diagrams to convey some notion of the physical conditions of these most instructive quarries.

4. IRELETH Slate Quarries.



NOTE.—In the above diagrams the arrows below the base line point to the direction of the cleavage planes and those above the section to the bedding.

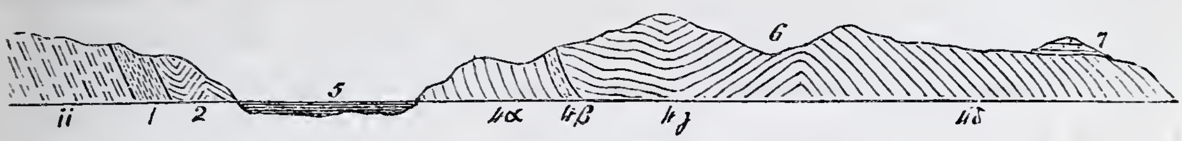
Most of the beds show spherical concretions,—sometimes filled with an earthy ferruginous matter like the Derbyshire rotten-stone; sometimes in the form of septaria, with calcareous veins. In these balls are found a few ill-preserved fossils, such as Encrinite stems, Graptolites, corals, and Orthoceratites. Mr. Salter has identified one Orthoceratite with *O. subflexuosum* of Münster. Of Graptolites there are probably two very nearly allied species,—one is *G. ludensis*. Among the corals is *Favosites alveolaris* and a *Cyathophyllum*.

4 δ. To the description of the coarse upper slates I have little to add to the details before given. Many parts of it can hardly be distinguished from the preceding group. It contains numerous concretionary balls, with *Graptolites ludensis* and corals like those of the preceding sub-group (γ). It also contains (though rarely) *Cardiola interrupta*, as is stated in the published abstract of my former paper. The previous descriptions apply only to the country of Low Furness. To assist in making them understood I here give two sections,—one from the Coniston limestone at the south-west end of Cumberland, thence across the Duddon estuary, and over the hills of Furness to the sea near Ulverston (see diagram 5).

5. MILLAM, through DUDDON SANDS to the sea near ULVERSTON*.

N. S.

Millam. Duddon Sands. Osmotherly. Ulverston.



The other section (No. 6) commences with the same limestone, and crosses the sands about two points of the compass farther towards the south, so as to reach the south-east shore on the south side of a great fault or contortion which has repeated the Coniston limestone in High Haume near Dalton.

6. MILLAM through DUDDON SANDS to DALTON.

Millam Park. Duddon Sands. High Haume. Dalton.

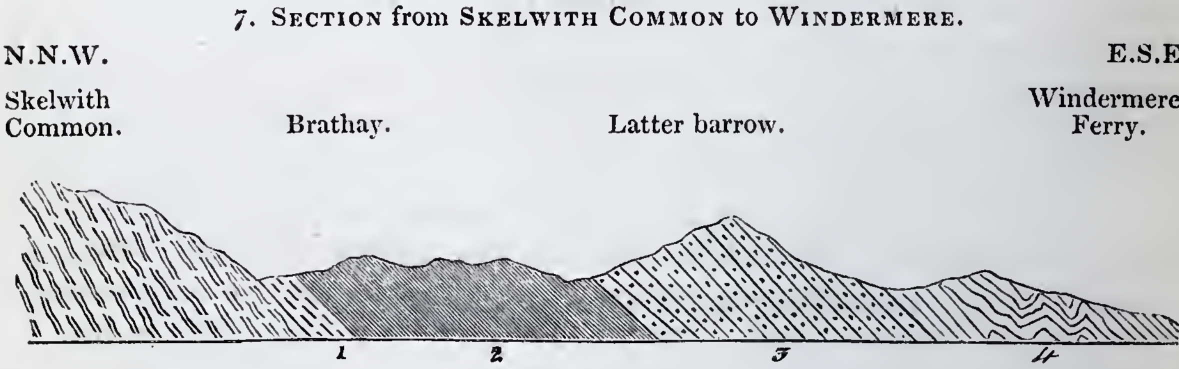
The preceding descriptions apply to the group No. 4 (α, β, γ, δ), as developed in Furness; and the aggregate thickness is very great—certainly several thousand feet. If the section were prolonged across Leven Sands, over the hills to Cartmell, it would probably bring in still higher beds. All the accidents of structure are however repeated, and are precisely like those on the Ulverston side of the Sands. Again, it is easy to make a section farther north from the Coniston limestone down Russland to Newby Bridge, and thence as far as Lindal. The lower part of such a section would give the groups 1, 2, 3, 4, in great perfection and clearness, and would cross three distinct lines of porphyry dykes; and near Newby Bridge the section would terminate in some part of the group 4 δ. This last part of the series has however very few fossils, but in the abstract before referred to I have already mentioned *Cardiola interrupta*. Starting with this section the strike is north-east; at Newby Bridge the strike is various, and the masses are enormously shifted at the intersection of three valleys. The prevailing strike is about N.N.E. or north by east; thence passing over the ridge to Lindal there are perhaps twenty anticlinal and synclinal lines. At Allithwaite the chain is broken, and beyond that village, down to Lindal, the strike becomes north by west or N.N.W. I conceive it therefore almost impossible to connect this end of the section correctly with any section from Coniston down Russland to the foot of Windermere. Still, on the whole, the sections are in the ascending order towards the south-east, and we gradually reach the upper limits of No. 4.

* It is proper to state that in this and some of the other diagrams illustrating the present memoir, the appearance of a want of conformability (*e.g.* between 4 β and 4 γ *supra*) is an error in the engraving. *All the beds*, from No. 1 to No. 5 inclusive, are in fact conformable throughout the district.

Nor is this the only difficulty. From the absence of the calcareous band (4 β), all the subordinate groups are packed in one mass; and the impress of slaty cleavage, notwithstanding the extraordinary contortions and dislocations, affects them all. These cleavage planes strike, in almost undeviating lines, through all the complicated curves and broken masses, in a direction on the average within a point of magnetic east and west. In the Ireleth ridge the cleavage planes hang toward magnetic south; but further north, the same planes (nearly with the same strike) hang within a point of magnetic north, generally inclining towards true north. I think these phænomena theoretically important, and I hope to return to them in a future communication.

These reasons are sufficient, mineralogically, for grouping together all these slaty masses over the hard grits (No. 3). Neither do the fossils indicate the expediency of any further subdivision under the name of Windermere rock, or any other local name. The more slaty masses out of which roofing-slate is extracted, may in a general way follow particular zones, but they are not continuous, and I believe they often shift their parallels. This is the case in the older Cumbrian slates, and also, I believe, in the group I am describing (No. 4 γ). Still we may in an approximate way follow on the strike the lower slates (4 α), and the higher (4 γ). The latter I would place near the foot of Coniston Water, and thence across Hawkshead valley to the shore of Windermere, a little below the Ferry. This is, I think, nearly the range given in Mr. Sharpe's last abstract. But if this be true it follows that the slaty beds extending to Latterbarrow must represent the group (4 α).

7. SECTION from SKELWITH COMMON to WINDERMERE.

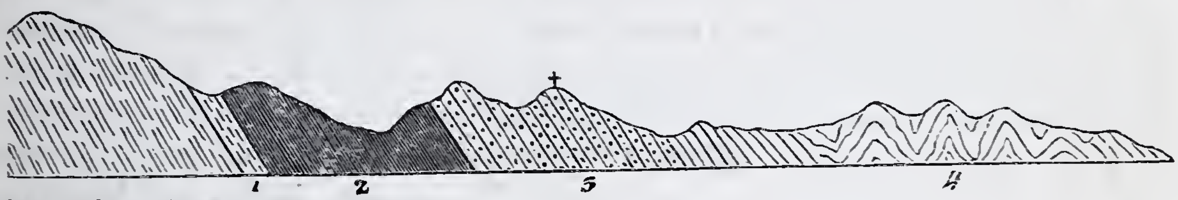


Now in this group we have fossils; and in some bands on the right-hand of the road from the Ferry-house to Hawkshead, we find several species of fossils, and the *Terebratula navicula* in vast abundance. I do not contend that the bands with *T. navicula* exactly represent (4 β) or upper limestone; neither would I bring them into exact comparison with the Aymestry limestone of Siluria. The comparison would be too wiredrawn to be of any use; and, by like reasoning, we might prove the existence of three or four bands of Aymestry limestone on different geological parallels. Following the several groups along the line of strike over Coniston Water and Windermere, and thence through an undulating country of singularly contorted strata into the valleys of Kentmere and Long Sled-

dale, and to Bannisdale Foot, on the road from Kendal to Shap, we have repetition upon repetition of the same phænomena. None of the groups die away; and there is no unconformable overlap (as has been stated) whereby the highest group (4 δ), under the name of Windermere rock, is made to pass over the edges of the older groups α, β, γ. The hypothesis is, I think, positively contradicted,

8. SECTION from WANSFELL PIKE to CROOK MILL.

N.W. Wansfell Pike. Troutbeck. Station. S.E. Crook Mill.



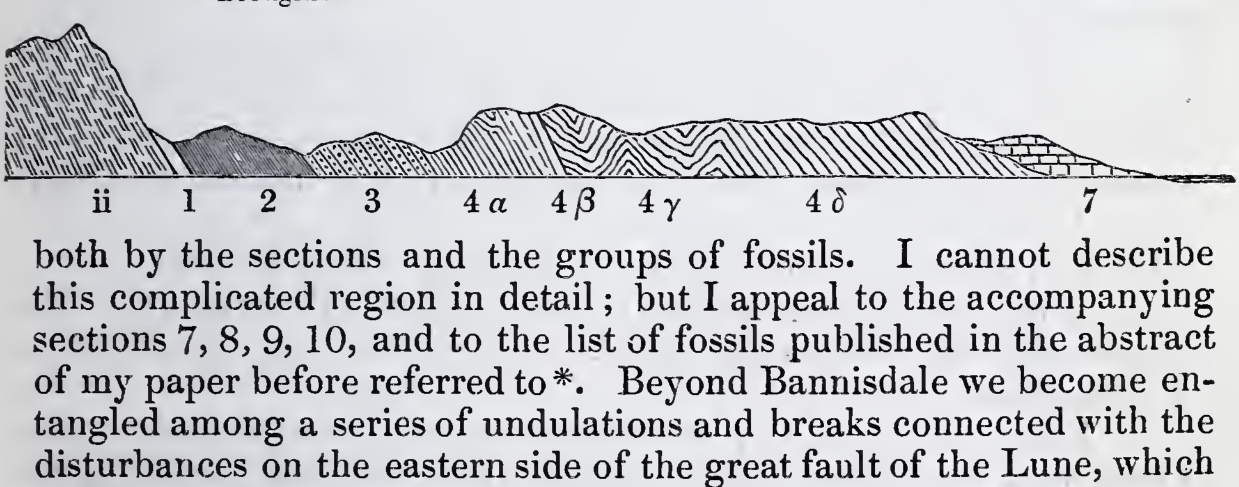
Slate and porphyry.

9. SECTION through CROOK and UNDERBARROW to KENDAL.

N.W. by N. Ambleside Turnpike. Crook Ch. Underbarrow Ch. E.S.E. Kendal Fell.

10. SECTION from near BROUGHTON to ULVERSTON.

N.W. Broughton. S.E. Sea near Ulverston.



ii 1 2 3 4 α 4 β 4 γ 4 δ 7

both by the sections and the groups of fossils. I cannot describe this complicated region in detail; but I appeal to the accompanying sections 7, 8, 9, 10, and to the list of fossils published in the abstract of my paper before referred to*. Beyond Bannisdale we become entangled among a series of undulations and breaks connected with the disturbances on the eastern side of the great fault of the Lune, which will be described presently. I may also here refer to the coloured map of Westmoreland†. The colours are meant to illustrate this paper, but the phænomena are only local. Were I employed in colouring a geological map of England on the scale of that by Mr. Greenough, I should still use one simple colour for the whole series of four groups, No. 1 having a distinct colour, as it would I think be impossible to follow these subdivisions from one county to another in the subordinate details, so as to lay them down on a map, however great the scale.

* Journal, *ante cit.* vol. i. p. 442 *et seq.*

† Presented to the Geological Society.

5. *Upper Slate of Kendal and Kirkby Moor.*—This group is divided into three sub-groups, 5 *a* surmounted by 5 *b*, and 5 *b* terminating in the ascending order with a red, grey and greenish flagstone (5 *c*), overlaid by conglomerate of the old red sandstone.

(5 *a*.)—The lower subdivision is ill-defined, especially at its lower extremity, because it forms a passage (both in its mineral structure and its fossils) into No. 4. If we commence near the ridge (above alluded to at Lindale), and cross the marshes to the great outlier of Witherslack (mountain limestone); or if we cross from Underbarrow by the turnpike-road to the great limestone outlier of Kendal Fell; or lastly, if we start from Bannisdale Foot from an ill-defined base affected by the great troubles of the Lune, in each of these cases we cross the several beds of the sub-group 5 *a*.

The lower beds are affected by slaty cleavage, but among them occurs the *Terebratula navicula*. The upper beds are less and less slaty, and contain so many fossils of the well-defined upper group between Kendal and Kirkby Lonsdale, that my friend Mr. Salter could hardly make out any palæontological difference between this group (5 *a*) and the upper (5 *b*). But considered in its details, there is a difference. The upper part wants the hard micaceous gray and greenish-gray sandstones with the species of large *Avicula*, *Cypricardia*, &c.; and it contains abundantly several fossils, such as *Asterias*, *Ophiura*, &c., very rarely if ever found in the hills between Kendal and Kirkby Lonsdale.

The best illustration of this ill-defined sub-group is between Underbarrow and Kendal Fell, and I hope hereafter to describe this section in more detail (see *ante* fig. 9). It is enough for my present purpose to mention the following facts.

1. Commencing at Underbarrow among the faulted beds of the valley, we have slate and flag, with a rude cleavage whose direction is magnetic north. In this series is *Terebratula navicula*. This species, counting from the beds north-east of Windermere Ferry, must therefore have a very great vertical range. These beds terminate in ascending order near a farm called High Thorns.

2. A thin bed with *Asterias* (six or seven feet), above which the *Terebratula navicula* is not found. [Here is the last appearance of *Turbinolopsis*.]

3. Flags, *sheer bate* (*i. e.* without cleavage), some red calcareous bands with very many fossils. Many Trilobites (one like *Calymene Blumenbachii*.)

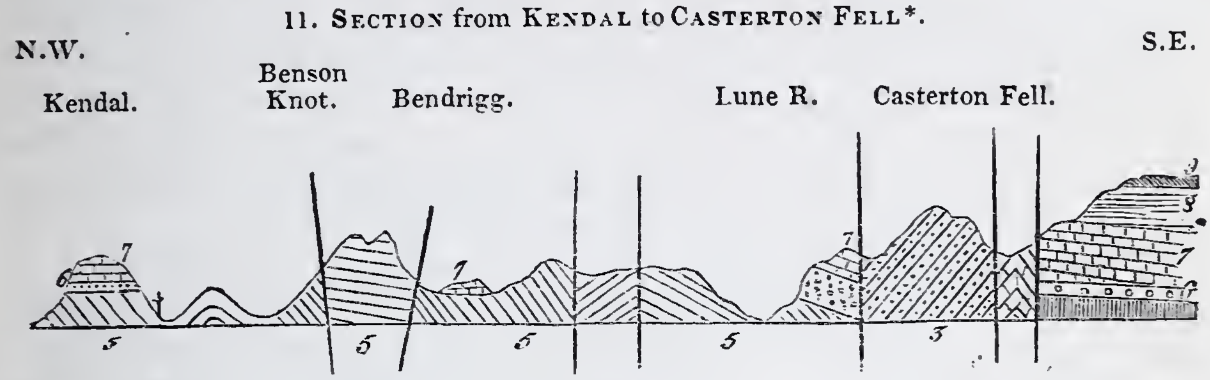
4. Striated hard grits and *sheer bate* flags, with many fossils like those under the great Avicula beds of Benson Knot, on the north side of the Kent.

The Asterias beds (No. 2 of this section) are found at Docker Park, in the beds under Benson Knot, in the valley above Kendal near Redman Tenement, and in the Sprint rivulet about a mile below the Tenement. Here, therefore, we have a passage into the upper and higher sub-group 5 *b*.

(5 *b*.)—Respecting this group there has been no difference of opinion. It must be nearly on the parallel of the Upper Ludlow, and

it ends near Kirkby Lonsdale with a tilestone (5 *c*), the upper part of which (on the banks of the Lune) contains red calcareous concretions, immediately under Red Scar (old red sandstone). The map and the accompanying section (diagram 11) will explain the manner in which

11. SECTION from KENDAL to CASTERTON FELL*.



this formation has been shattered into vast fragmentary masses. The collocation of the masses can only be explained by the interference of two or more lines of dislocation. But among all these dislocations, we may often trace the rudiments of the original north-east strike of the Lake mountains. As far as I know the sections, no older beds are brought up between Kendal and Kirkby Lonsdale. I have not at Lupton Fell, or anywhere else in this district, seen a trace of the groups of (No. 4): all here is Upper Ludlow. I may here call attention to a patch of mountain limestone (at High Bendrigg) which has been laid bare by the bursting of the canal reservoir, and is a striking instance of the vast denudations and convulsions which have affected this singularly broken region. A large list of fossils obtained from this sub-group has already been given, and I could now add considerably to it. In one word, then, the whole fossiliferous series above-described begins with rocks of the Lower Silurian type, which are only a few hundred feet thick (200 or 300 feet on the average, and 600 feet at the maximum), of the age of Llansaintffraid and Mathyrafal beds, and these are not, as I once supposed, on the parallel of the Bala limestone. All the other rocks are Upper Silurian, and there is no unconformable overlap of Windermere rocks to be distinguished from the general series from No. 2 up to No. 5. The subdivisions of the groups do not resemble those of Siluria, neither does the minute arrangement of the species; but there is a general resemblance amongst the species and Upper Siluria and Westmoreland, which considered as one great group, are almost identical, and both end with the same mineral type, viz. a red flagstone or tilestone.

Lastly, the development of the Upper Silurian series (not resembling that observed in Siluria) does, on the other hand, resemble that in South Wales, nine-tenths of the higher slate mountains of which, I doubt not, will prove Upper Silurian.

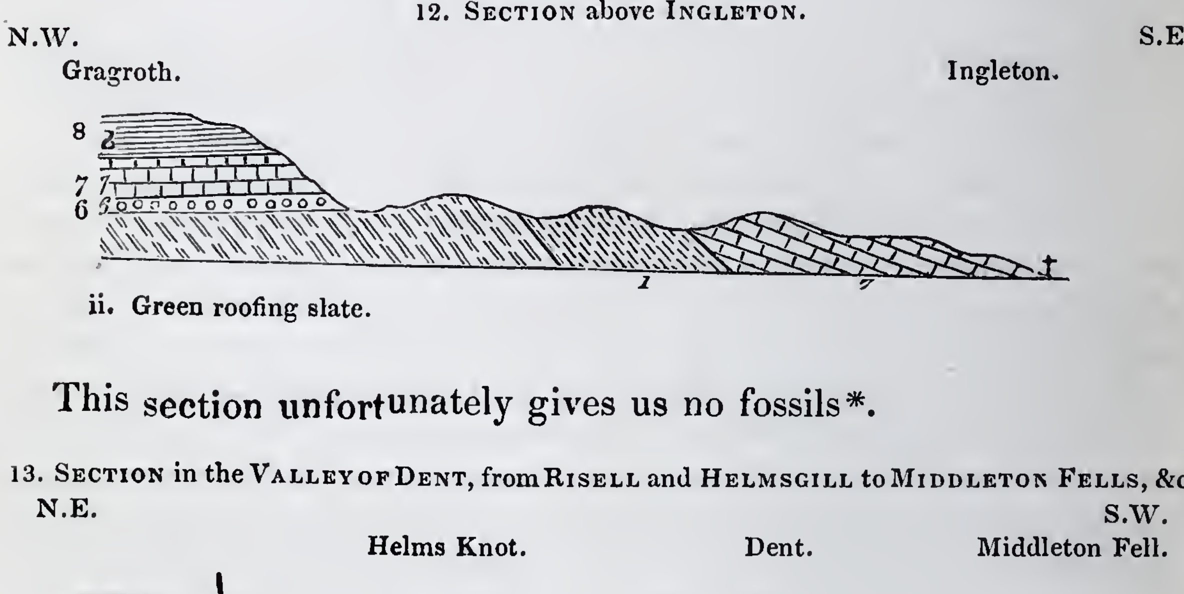
* In this diagram the number (5) refers to the upper sub-group (5 *b*), and the lines projecting beyond the outline of the section represent the faults. The number 8 refers to the great limestone shale ('Yoredale series' of Phillips), and number 9 to the lowest millstone grit.

§ 3. *Structure of the Mountain-chains of Howgill, Ravenstonedale and Middleton, on the east side of the Valley of the Lune.*

I will not here detain my readers with any account of the picturesque features of these beautiful mountain-chains, or my rambles through their defiles and precipices. The great undulations of the district are among the most remarkable I have ever studied; and I would also refer to that break of the strata which ranges up the valley of the Lune, and in the upper part of the valley deflects towards the north-west, and is connected with a great trouble which brings up the hard grits (No. 3) at Whinfell Beacon.

The great difficulty among these extraordinary undulations is to find a true geological base-line on which we may construct a regular and consistent system. Indications of such a base-line I have already pointed out in my former paper; viz. the appearance of Lower Silurian fossils near the range of the great Craven fault through the valley of Dent. A careful examination of the whole fault, and of the slate rocks near it, enables me now to state that there is a good base-line nearly all along the eastern skirts of the troubled district, that base being the Coniston limestone (No. 1). The evidence will be best understood by sections.

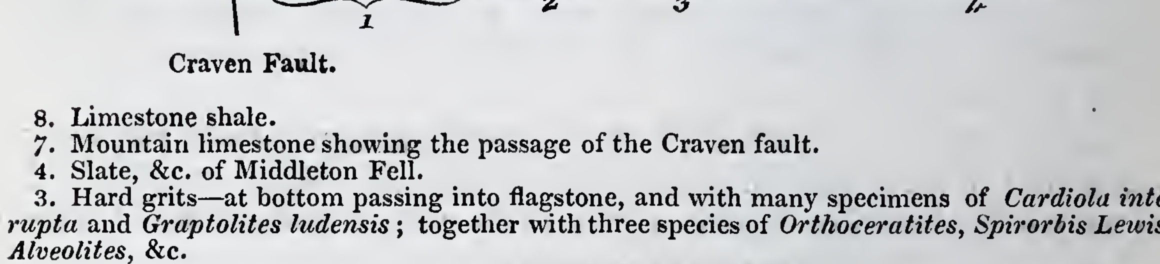
12. Section above Ingleton.



ii. Green roofing slate.

This section unfortunately gives us no fossils*.

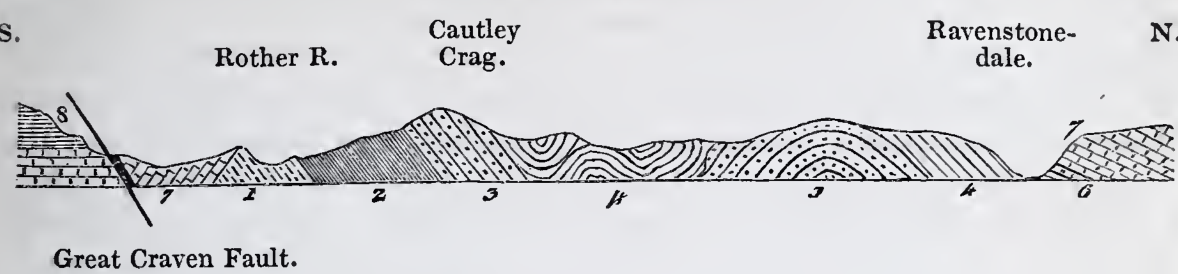
13. Section in the Valley of Dent, from Risell and Helmsgill to Middleton Fells, &c.



8. Limestone shale.
7. Mountain limestone showing the passage of the Craven fault.
4. Slate, &c. of Middleton Fell.
3. Hard grits—at bottom passing into flagstone, and with many specimens of *Cardiola interrupta* and *Graptolites ludensis*; together with three species of *Orthoceratites, Spirorbis Lewisii, Alveolites*, &c.
2. Calcareous flagstone with *Graptolites ludensis* and *Cardiola*.
1. Shale and limestone with fine series of Coniston fossils intersected by porphyry dykes.

* The Craven fault must pass somewhere between the two masses of mountain limestone to the extreme left and extreme right of the section, but its exact place is not laid bare.

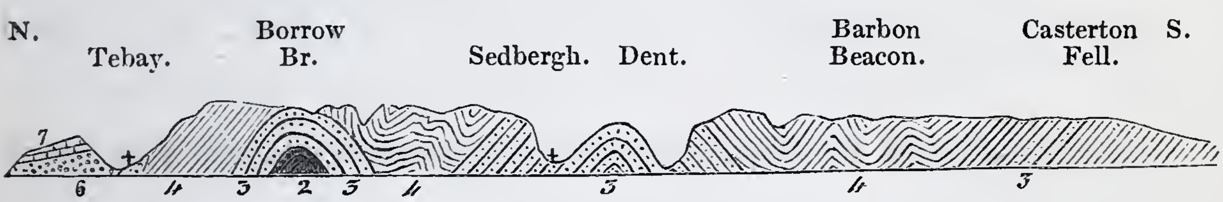
14. SECTION from the higher part of the VALLEY OF SEDBERGH, over CAUTLEY FELLS to RAVENSTONEDALE.



8. Limestone shale overlaid by millstone grit.
7. Mountain limestone broken by the Craven fault.
4. Contorted slates, &c., ending with old red (6) and mountain limestone of Ravenstonedale*.
3. Hard grits.
2. Flagstone with Graptolites:—Orthoceratite with an encrusting coral.
1. Calcareous slates and limestone with fossils. A little above the line are many porphyry dykes, and farther on the strike of the same beds, a magnificent series of Coniston fossils, perhaps the richest deposit of this age in the north of England.

These are instructive sections, and tell a very plain story. They enable us also to interpret other sections, which might be considered doubtful and obscure without their help.

15. Great North and South SECTION from TEBAY to CASTERTON FELL.

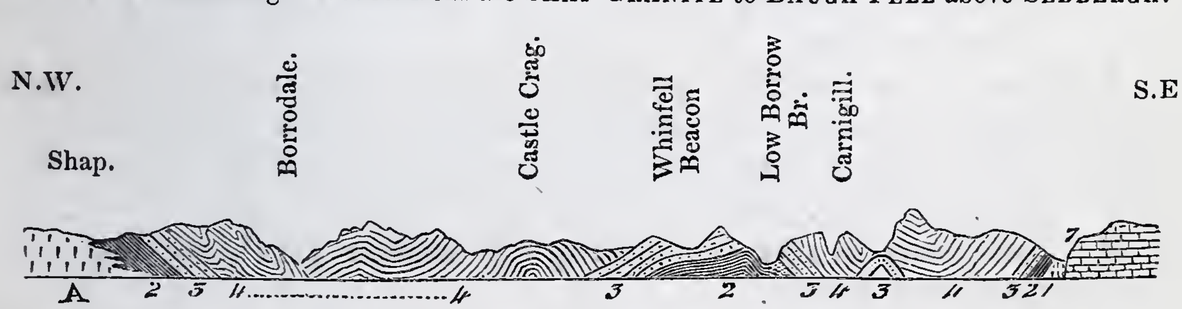


From this section it appears that the Coniston grits (3) and Ireleth slates (4) are repeated by great undulations. In one spot the calcareous flag (No. 2) (with *Graptolites ludensis*) makes its appearance; and the whole series at the north end is overlaid by old red conglomerate (6) and mountain limestone (7).

In the grits (No. 3) of Casterton Fell are *Orthoceratites subundulatus*, *O. Ibex*, and *Cardiola interrupta*.

In the slates of Middleton Fell and Howgill Fell (No. 4) are *Avicula*, a small species; *Orthoceratites subundulatus*, a coral resembling *Monticularia* and *Alveolites fibrosa*.

16. Great connecting SECTION from the SHAP GRANITE to BAUGH FELL above SEDBERGH.



4. Ireleth slate series.
3. Coniston grit.
2. Coniston flag much indurated near the granite.
A. Shap granite throwing veins into No. 2.

* At the end of the slate series (4) in Ravenstonedale *Calymene* (*Downingiæ*?) occurs.

The north-west end of this section which passes through Nos. 2, 3 and 4 of the tabular section (see page 108), is intersected by three or more porphyry dykes; and at its south-east end it traverses the Howgill range, and descends into the valley above Sedbergh through the beds described in section 14. The whole country through which these sections pass is extraordinarily faulted and contorted, and the higher elevations, which are traversed by numerous porphyry dykes, exceed two thousand feet. Among the valleys indenting Howgill Fells is some wild and noble scenery, with two of the finest waterfalls in the north of England. Thus it appears, that in the remarkably contorted chains east of the great Lune fault, we have No. 1, 2, 3 and 4 of the tabular section in regular order, and that no higher rocks appear in the chains, which at both ends are overlaid by the conglomerates of the old red sandstone and by mountain limestone.

January 21, 1846.

Alfred Tyler, Esq., and Bland Hood Galland, Esq., were elected Fellows of the Society.

The reading of Professor Sedgwick's communication was resumed and completed.

Part II.

The former part of my paper, containing numerous detailed sections, did not include the conclusions I wished to draw from them. I there described the whole series of fossiliferous slates extending from the Coniston limestone to the valley of the Lune, as subdivided into five primary groups, viz.:—

5. Upper Ludlow rocks, including tilestone, extending from Kendal to the banks of the Lune, near Kirkby Lonsdale.
4. *Ireleth slates*, divided into four sub-groups (α, β, γ, δ).
3. *Hard gritty beds* approaching a conglomerate form, with subordinate slaty masses, having numerous spherical concretions arranged parallel to the beds. Fossils rare, but of Upper Silurian species.
2. *Coniston* or *Brathay flagstone*, having Upper Silurian fossils, and developed to a thickness roughly estimated at 1500 feet. The mineral structure almost identical with that of the flagstones of the Upper Silurian rocks of Sir R. Murchison, and yet more nearly resembling the Lower Denbigh flagstones of North Wales.
1. *Coniston limestone and calcareous slate* having Lower Silurian fossils.

Respecting the upper part of the great formation of the Ireleth slates (No. 4 δ) there is no difference of opinion, as it contains several well-known Lower Ludlow fossils, and has already been compared,

in a general way, both by Mr. Sharpe and myself, with the Lower Ludlow rocks. It forms a part of his Windermere rocks.

I formerly considered the three lower sub-groups (4 α, 4 β, 4 γ) as Lower Silurian; but I did so before I had re-examined the country (the most important part of which I had never seen since 1822), and I was, I believe, misled by confounding the High Haume limestone (south of the Duddon) with the upper calcareous band (4 β). I need not repeat what I have before stated on this head; but as Mr. Sharpe still appears to adhere to the supposition that these three lower sub-groups are *Lower Silurian*, I have lately re-examined my fossil evidence, as well as my field sections; and I adhere to my previous conclusions. In the first place, there is no evidence of any unconformable overlap (as stated, if I mistake not, in Mr. Sharpe's paper,) among the beds of the four sub-groups, and they form one unbroken continuous mass. And in the second place, the fossils of the four sub-groups compel us to class them all as one formation—nearly on the parallel of the Lower Ludlow rocks. The fossils of the rocks north of the Ferry House at Windermere have been re-examined by my friend Mr. Salter; several large fossiliferous masses which I brought away from these rocks have now been broken up, and the following is the list of fossils Mr. Salter has derived from them.

List of Fossils from the Rocks north-east of the Ferry House.

1. *Encrinites*, one or two species. One remarkable undescribed species also found in the valley of the Kent above Kendal, just under the Upper Ludlow rocks.
2. Fragments of a *Calymene*.
3. *Turbo carinatus* or *corallii*.

   Turbo? like a species in the Upper Ludlow of Kirkby Moor.

   Turritella obsoleta.

   ——— *conica*.

   Terebratula semisulcata (*T. lacunosa* of the Ludlow rock in the 'Silurian System').

   Orthis orbicularis.

   ——— *lunata*.

   Leptæna lata.

   Nucula, resembling *N. ovata*.

Here are twelve species—none of which are known Lower Silurian, and eight of which are known Upper Silurian species. And to this list we may add *Terebratula navicula*, obtained from the immediate neighbourhood. It appears therefore that there is no room for doubt; for these fossils are all derived from the *lower part* of the great group (No. 4).

It was however stated that the upper limestone, near Coniston Water-foot, contained Lower Silurian fossils; and the authority of Mr. J. Marshall was appealed to. Now I examined this part of the country during last summer in company with Mr. J. Marshall, and I venture to affirm that he did not show me a single Lower Silurian

fossil in this *upper limestone*; neither did he appear to have ever seen any. In quoting his authority there must, therefore, have been some mistake. Of the singular High Haume limestone I may just remark—that it is mineralogically unlike this upper limestone—that it is associated with a different series of rocks—that it contains a distinct series of fossils (viz. Lower Silurian), and that it is not on the line of strike of the upper limestone. But if we endeavour to identify the two limestones, (as I did myself in 1822, before I had studied the structure of the neighbouring country, or knew the fossils,) what then follows? That through a thickness of not less than 4000 or perhaps 5000 feet, there is an utter confusion of Upper and Lower Silurian types. I do not accept this conclusion: and I have now gone over the reasons for the classification I adopted in 1844, and confirmed by my examination of the same country in 1845.

I next examined the rocks of Ravenstonedale, Howgill Fells, and Middleton Fells. Their geological base is formed of a calcareous slate with impure beds of limestone, which in two or three places (especially Helmsgill in Dent, and Ravenstonedale, above Rother Bridge,) contain many fossils. I collected in about an hour at one small quarry in Ravenstonedale not less than twenty-five or thirty species*. From the very near agreement of these with Coniston limestone (Lower Silurian) fossils, we have a true geological baseline for the contorted region of Howgill Fells, and we have no lower rocks brought up in that mountainous region. Were these rocks of Ravenstonedale by themselves, and dissociated from the upper groups, there might perhaps be some doubt of their exact age. But they pass upwards into the most characteristic Coniston flags, with *Graptolites ludensis* and *Cardiola interrupta*; and these flags are in their turn surmounted by the hard grits (2) and the Ireleth slate (4). Hence the Howgill Fell system is only a repetition of the four lowest groups on the north-west side of the great fault of the Lune, folded over and over again by vast local undulations; and hence also it follows that the highest rocks of the Westmoreland series occur in a kind of irregular hollow or basin, with older rocks expanded along their whole eastern extremity: but there is no direct and unequivocal proof of any want of conformity in any part of the series till we reach the old red sandstone and the carboniferous limestone.

* Mr. Salter has given me the following extract from his list of these fossils:—

Orthis Actoniæ.
——— *flabellulum.*
——— *elegantula* (formerly *O. canalis*).
——— *alternata*, &c.
——— like *O. Pecten* (repeated at Coniston).
Leptæna transversalis.
——— *depressa.*

All the above are known Coniston fossils. The Ravenstonedale list also resembles the Coniston in the rarity or absence of certain fossils which abound at Bala, e. g. *Orthis vespertilio*, *Leptæna tenuistriata*, *Crania catenulata*, and a new species of Orthis. To these may be added some peculiar species of univalves and six or seven species of bivalves which occur neither in the Caradoc of Sir R. Murchison nor in the Coniston limestone.

The anomalous position of the masses has been probably caused by great faults and partial dislocations. I here subjoin a comparative view of the fossils in the Upper and Lower Silurian rocks of the country here described.

Comparative view of the Fossils in the Upper and Lower Silurian Rocks of Westmoreland.

Orders.	Species peculiar to Upper Silurian.		Common species.		Species peculiar to Lower Silurian.
Pisces	3 ?	...	—	...	—
Cephalopoda	17	...	1	...	3
Gasteropoda, Pteropoda, &c.	17	...	1 ?	...	2
Lamellibranchiata	34	...	—	...	—
Brachiopoda	15	...	2	...	19
Tunicata	2	...	—	...	1
Crustacea	5	...	1	...	11
Annelida	4	...	—	...	3
Echinodermata	4	...	—	...	2
Zoophyta	7	...	5	...	11
Total peculiar to Upper S.	108	...	10	...	52
— common species	10				
— peculiar to Lower S.	52				

Welch.
170 + 180 = 350 species {in North Wales and Westmoreland.

To these may be added from other localities about ... } 150 species.

Probable total of British Silurian species described ... } 500*

When it is considered what a fossil impress is given to these old rocks by the Cephalopoda, Gasteropoda, Lamellibranchiata and Brachiopoda, and that of these four families we have eighty-three species in the Upper Silurian rocks, and twenty-four in the lower, and only three species in common, the list shows a most marked difference between the two systems. On the whole, the list indicates a progress towards a higher organic structure as we ascend from the lower to the upper rocks. Again, the Crustaceans peculiar to the old rocks began in the earliest time, reached their maximum of development at a very early period, and then began to decline, so as not to pass the carboniferous epoch. Lastly, I may remark that the difference indicated in the list between the Upper and Lower Silurian fossils of the Lake mountains is probably greater than will be found true on further examination; because most of the fossils have been derived from the two extremes of the general section, viz. No. 1 and No. 5 of the tabular list, the intermediate parts not having been so well explored by the fossil collectors.

In confirmation of the preceding view, I subjoin another interesting table, supplied by Mr. Salter from Sir R. Murchison's descriptive lists.

* Several new species have been discovered since this list was made out.

Synopsis of the Silurian fossils as given in Sir R. Murchison's Work.

Of 267 species of *Mollusca* and *Articulata* described from the Silurian rocks,

106 are found in the	Ludlow series,	and 83	are peculiar to it.
55 ,,	Wenlock limestone,	,, 30	,,
41 ,,	Wenlock shale,	,, 21	,,
75 ,,	Caradoc,	,, 40	,,
39 ,,	Llandeilo flags,	,, 15	,,

	Species common to the various parts of the series in the				
	Ludlow.	Wenlock limestone.	Wenlock shale.	Caradoc.	Llandeilo flags.
Ludlow rocks	...	19	15	2	1
Wenlock limestone	19	...	15	7	3
Wenlock shale	15	15	...	10	5
Caradoc	2	7	10	...	20
Llandeilo flags	1	3	5	20	

NOTE.—In this synopsis the corals are rejected as too widely spread; the Crinoidea as being imperfect, and therefore difficult of identification, except in the Wenlock limestone; so that Trilobites and shells only are taken for the comparison.

It appears from the other tables, that out of fifty-five species in the Wenlock limestone, nineteen are common to the Ludlow series and fifteen to the Wenlock shale; and that out of forty-one species in the Wenlock shale, fifteen are common to Lower Silurians, ten being Caradoc and five Llandeilo species.

6. If we take the Wenlock limestone and Wenlock shale together, we have only sixty-four species, nineteen in common with Ludlow rocks and nineteen with the Lower Silurians; or in other words, about one-sixth of the whole Ludlow series, and more than one-fourth of the Lower Silurians. The Wenlock series is therefore truly intermediate; but it is very imperfectly represented in the north of England for want of any rich bands of limestone of the Wenlock age.

To the comparisons I have instituted in former communications between the Upper Silurian series of Westmoreland and North Wales I have little to add. The lower part of the Denbigh flags appears to be exactly on the same level with the Coniston flags (No. 2), and the whole development of the Upper Silurian rocks in North Wales (with many points of local difference) has many points of general resemblance. The sequence in Westmoreland is however more perfect than in North Wales, and in neither county is the development at all resembling that of Siluria. Beautiful as the sequence of that county is, it is not the true mineral type either for England, Wales, or Ireland. As a general rule, I believe that all limestone bands below the carboniferous series are mere local phænomena, appearing at intervals, which are perfectly irregular in countries remote from one another. This remark is meant to include Devonian limestones, and all Silurian limestones, both upper and lower, and many other limestones far below those which mark the beautiful sections of Siluria. Hence we can only identify large subdivisions; and any attempt at the comparison of subordinate parts must often end in positive error. Whether this remark applies to the older rocks of

North America, I do not presume to judge; but it applies to the general European type as far as I have any knowledge of it.

South of the Berwyn chain and the valley of the Upper Severn, the comparison of the Westmoreland sections with the Upper Silurian rocks is more difficult. They there appear partly as flagstones, but more generally as coarse greywacke and greywacke slate, in vast alternating masses thrown into continual undulations. These undulating masses run far towards the south, and, if I mistake not, cover very large tracts of the higher parts of South Wales. Mineralogically they are almost identical with the hard grits (No. 3) and the Ireleth slate (No. 4) of the sections of Westmoreland and North Lancashire. I formerly identified them in the countries above mentioned under the name of Upper Cumbrian. During the past summer, Mr. Salter, at my suggestion, paid a visit to the part of Wales last indicated, and the result of a traverse he made from the neighbourhood of Builth to Aberystwyth was rather negative than positive. He found hardly any fossils* ; and he was thus unable to separate the great series of undulating strata, including Plynlimmon, from the undulating grits and slates at the south end of the Berwyn chain. This was what I expected, and what I had before affirmed as probable; and it induces me to place (at least provisionally) all the Plynlimmon system among the Upper Silurian rocks of Sir R. Murchison; and I believe (though I must acknowledge upon a very imperfect examination, carried on only during a few days in 1832) that the same upper rocks extend much farther south, and occupy by far the greater part of the higher regions of South Wales; of course excluding from this remark the country of the Old red sandstone and the carboniferous series. But how reconcile this with the statement more than once made by Sir H. De la Beche, that the *Llandeilo flag* was repeated more than once in the undulations of South Wales, and far to the north of the line of Landeilo flag drawn on Sir R. Murchison's map? The answer to this question involves another—what is the age of the Llandeilo flag?

Sir H. De la Beche has stated repeatedly that the *Asaphus Buchii* is found in some parts of South Wales among Wenlock shale fossils: and among the highest beds of the Caradoc sandstone, just where at Mathyrafal it passes into the upper flagstone, Mr. Salter, in the year 1843, pointed out to me three or four good Wenlock shale fossils, which also occur in the Llandeilo flag†.

* A Lower Silurian *Pleurotomaria* however occurred at Dol-fan.

† The following species are common to the Mathyrafal series and the Llandeilo beds :—

Orthis lata.	*Atrypa lens.*
Atrypa crassa.	*Leptæna transversalis.*
—— *undata.*	—— sp. n.
—— *globosa.*	

The following are common to Wenlock and Llandeilo beds :—

Orthoceratites subflexuosum.	*Leptæna euglypha.*
—— *annulatum.*	—— *transversalis.*
Orthoceratite. A smooth species (s. n.).	*Calymene Blumenbachii.*
Lituites Cornu Arietis.	*Trinucleus Caractaci.*
Leptæna depressa.	*Paradoxites bimucronatus*, &c. &c.

At the time, this surprised me greatly; but the fact is quite in harmony with the statements of Sir H. De la Beche. All the sections of the Silurian system south of the Severn are made on the hypothesis that the mountains on the north-west side of the lines of section are older than the Silurian rocks. Now, as a general rule, this hypothesis is not correct, and it in some measure vitiates the base-lines of the several sections, and so destroys a part of their meaning. But the section at the east side of the Berwyns, ending with Craig y Glyn, is appealed to by Mr. Murchison as proving the low position of the *Asaphus Buchii* and the Llandeilo flag. For several years I myself put this interpretation upon the section in question. But since a doubt has arisen about the age of the Llandeilo flag, Mr. Salter has re-examined the specimens both from Craig y Glyn on the east flank of the Berwyns, and also from one or two localites near Grat Arrenig and in the Rhiulas limestone; and he now retracts his identification of any of the fragments with *Asaphus Buchii.* The only fragments he can identify belong to *Asaphus tyrannus,* which certainly has a very low range among the fossiliferous slates. The evidence therefore supplied by my sections in North Wales gives us no help in determining the age of the Llandeilo flag. Mr. Salter also examined during the past summer one or two sections of the Silurian series of South Wales. I cannot give his remarks in detail; but I may state the result of them. They go to prove either that the Llandeilo flag is not inferior to the Caradoc sandstone (*e.g.* at Builth), or that it is associated with the upper part of it, a part containing several fossils of the Wenlock shale or limestone. Hence, coupling these remarks with what has been stated by Sir H. De la Beche, I should class the Caradoc sandstone and Llandeilo flags of South Wales, the Caradoc sandstone of the Malverns, that on the south-east side of the Berwyns, and lastly, the fossiliferous bands of Glyn Ceiriog and Mathyrafal, all in one group, and compare it with that of the Coniston limestone; perhaps including with the Coniston limestone also the Coniston flags*. If this view be correct, we cease to be surprised at finding the Llandeilo flags among the great folds and undulations of the Upper Silurian rocks of South Wales. The *Calymene Blumenbachii* ranges from the Ludlow and Wenlock limestone down to the rocks under the Caradoc sandstone, &c. The *Trinucleus Caractaci* is a most abundant Caradoc sand fossil, yet it ranges into the Wenlock shales under Wenlock Edge; and were I to seek for the *Asaphus Buchii*

* Of 45 species of Trilobites and shells found in the Llandeilo flags—
 3 are Wenlock species exclusively.
 10 common to Wenlock, and the Glyn Ceiriog and Mathyrafal series.
 10 Mathyrafal and Glyn Ceiriog.
 1 Coniston only.
 1 Irish Wenlock—Kerry.
 5 found in the Caradoc.
 —
 30, leaving 15 as peculiar to it.

Only 9 Coniston species are contained in the Llandeilo series. The additional species were added by myself (39 is Sir R. M.'s number) at Builth last year.—J.W.S.

in the Cumbrian mountains, it would be among the flagstones associated with or overlying the Coniston limestone*.

Though there are several remarkable species of mollusca and crustacea common to the Wenlock, Caradoc and Llandeilo series, there are other beds far below them which, I believe, contain none of these common species. These beds are subordinate to the most remarkable physical group of England. I have in former papers called it the *Protozoic group*; or the lowest and greatest division of the rocks with Lower Silurian fossils. Now that I have no evidence of the existence of *Asaphus Buchii*, and other Llandeilo characteristic fossils in this vast group, I am no longer embarrassed for its name. I cannot speak of a *Cambrian system*, with peculiar fossils found in no other; but I may speak of the lower or great *Cambrian group*; and it is, I think, on very probable evidence, placed on the same level with the green slates and porphyries of Cumberland, which I once called the great *Cumbrian group*. In this great Cambrian group began the lowest fossil species we know in the British Isles. Many of the lowest species lasted throughout the whole Lower Silurian period; but new species were added, as conditions gradually changed, during the epochs marked in the ascending sections; so that the lower fauna reached its maximum of development in the Caradoc sandstone and Llandeilo flagstone. Afterwards the fauna underwent a much more rapid change, certain tribes of *Brachiopoda* diminishing in numbers, and being replaced by other forms, while, as far as our evidence goes (at least in the north of England), the *Lamellibranchiata*, though beginning low in the Cambrian group, also formed a more important part of the fauna of the Upper Silurian rocks. Geology tells us of the successive revolutions and changes in the crust of the earth. Organic changes are our surest guides in making out this history; but they form only a part of our evidence, and the great physical groups of deposits, however rude and mechanical, are historical monuments of perhaps equal importance in obtaining any true and intelligible history of the past ages of the earth; and after we have descended through a certain number of stages, they become indeed our only monuments and indexes of past events. This is true in North Wales,

* Of the Coniston Lower Silurian fossils (including Helmsgill, &c.) we find in North Wales—

Peculiar to the Bala limestone and beds below it	6	species.
Common to the Bala series and the passage beds	16	,,
Peculiar to the passage beds	17	,,
Peculiar to Westmoreland	21	,,
	60	

By 'passage beds' are meant the highest beds of the Caradoc sandstone (*e. g.* those of Glen Ceiriog, &c.), which form a passage into the Upper system.

Of the 21 species which are peculiar to this series in the north of England, two occur in the beds on top of the Berwyns (Rhiwargor); two in Ireland, in beds referable to Wenlock limestone and shale; and three are characteristic Wenlock fossils, namely *Cyathophyllum cæspitosum, Cornulites serpularius, Tentaculites ornatus.*

Of course this list is not absolute; and the probability is, I think, that there will be no species "peculiar to the Bala series" when we know more.—J. W. S.

and still more emphatically in Cumberland, where the Skiddaw slate is without fossils.

Taking the whole view of the case therefore as far as I know it, I would divide the older palæozoic rocks of our island into three great groups—each (in local descriptions) to be further subdivided. They would then stand thus :—

3rd, Upper group, or *exclusively Upper Silurian.*
2nd, Middle group, or *Lower Silurian*, including Llandeilo, Caradoc, and perhaps Wenlock.
1st group, or *Cambrian.*

This arrangement does no violence to the Silurian system of Sir R. Murchison, but takes it up in its true place ; and I think that it enables us to classify the old rocks in such a way as to satisfy the conditions both of fossil and physical as well as of mineralogical development.

The general conclusions which I obtain from the details given in the former paper and the present one are briefly these :—

The fossiliferous slates, extending from the Coniston limestone to the valley of the Lune, are subdivided into five formations or primary groups.

5. Coarse slates, generally without transverse cleavage planes, grits, flagstones, &c., divided into three sub-groups.

γ. Greenish-grey and red flagstones (*tilestone*).
β. Grits and slates without true cleavage planes, with numerous Upper Ludlow fossils.
α. Coarse slates passing downwards into 4 δ.

4. A formation of very great thickness (*Ireleth slates, &c.*), divided, for convenience of description, into four sub-groups :—

δ. Coarse slates and grits,—often passing into the structure of the lower sub-groups, and not to be separated from them.
γ. Upper or great Ireleth slate zone.
β. Upper limestone.
α. Lower Ireleth slates.

Respecting the upper part (δ) of this great formation there is no difference of opinion. It contains beds of *Terebratula navicula* and several other well-known Lower Ludlow fossils ; and has already been compared, in a general way, with the Lower Ludlow rocks, both by Mr. Sharpe and myself.

3. A great deposit of hard gritty beds, sometimes even approaching a conglomerate form, with subordinate slaty masses, and with numerous large spherical concretions arranged parallel to the beds. The fossils are very rare in this group, but among them are *Graptolites ludensis*, *Cardiola interrupta*, *Orthoceras ibex* and *O. subundulatum*. All the species are Upper Silurian.

2. *Coniston Brathay flagstone.* Thickness roughly computed at 1500 feet. Its most characteristic fossils are *Graptolites ludensis*,

Cardiola interrupta, Orthoceratites (including *Creseis*), and a few Trilobites. The species are all Upper Silurian,—using that term in the sense given to it by Sir R. Murchison. The mineral structure of this formation is almost identical with that of the Upper Silurian flagstones of the Lower Severn, described by Sir R. Murchison, and still more exactly identical with the lower Denbigh flagstones described in my paper on North Wales.

1. *Coniston limestone and calcareous slate.* On an average not more than 200 or 300 feet thick; at a maximum (in Millam) about 600 feet thick. The fossils of this group are Lower Silurian, and I need not repeat the well-known list of species.

The whole series is overlaid unconformably by the old red sandstone and mountain limestone.

Note.—It is right to state that in this paper the localities of Wenlock fossils and those of Llandeilo flags, &c., are taken from Sir R. Murchison's descriptions (excluding Marloes Bay). One or two species were added from Builth by myself.—J. W. S.

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2. *On the Strata called* "Jackstones" *at* Merthyr Tydvil. By Jos. Dickinson, Esq., F.G.S.

Considering these stones in connexion with the ironstones and other strata with which they are associated, they are chiefly remarkable for the peculiarity of their structure and the great quantity of carbonate of lime which they contain. Few of the ironstones and scarcely any of the other strata in the coal-measures in this locality contain five per cent. of carbonate of lime, whilst these Jackstones contain forty-five.

Their usual structure is conical, the stones being made up of a series of distinct cones with serrated edges inserted into each other, having the apex of each cone directed towards the top of the stratum, although this is not invariably the case. The height of the cones is various, but those most perfectly formed seldom exceed four inches. Towards the upper and lower surface of the stratum, the conical structure frequently disappears and an even arrangement ensues.

These stones are disposed in seams similar to those of clay ironstone. They are of a brown and sometimes of a grey colour. They generally lie underneath and in contact with ironstone, and occasionally they intervene as a band in the middle of a seam, in which case, as well as in the former, there is generally a distinct line of division at the junction of the two stones. In many examples, however, the two stones blend imperceptibly with each other.

The thickness of a stratum of Jackstones seldom exceeds nine inches, and probably not more than three or four different strata could be enumerated in one section. They are generally situated amongst the ironstones lying below the workable coal-seams, the lowest of which is about 210 yards above the mountain limestone.

The analysis of one of the commonest specimens is—

Moisture	1·0
Carbonaceous matter	1·0
Alumina	10·2
Silica	10·8
Proto-carbonate of iron	27·5
Carbonate of lime	45·0
Carbonate of magnesia	3·8
	99·3

From their containing iron and lime, they are partially used in the blast furnaces at the iron-works; they have been also used in the manufacture of a cement; and in the neighbourhood of the mines they are employed to repair roads, for which purpose they are well adapted.

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3. *Notices of some Fossils found in the Coal Formation of* Nova Scotia. By John William Dawson, Esq.

Plate VIII.

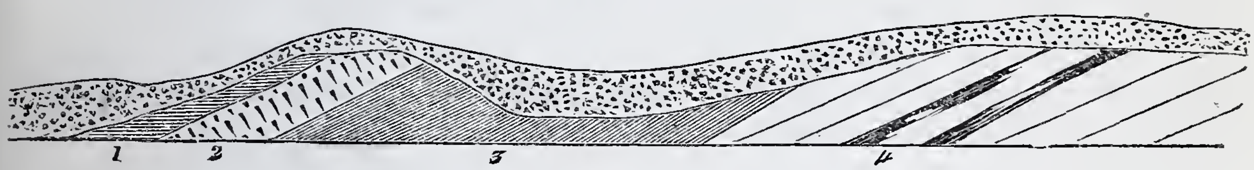
1. *Ichnolites.*—The coal-formation of Nova Scotia has already yielded ichnolites of three species, specimens of which, all unfortunately very imperfect, have been presented to the Geological Society by Mr. Logan and the writer of the present paper*. Desiring to add to the value of this discovery, I spent several days of last summer in a careful re-examination of the red sandstones at Tatmagouche, which had formerly afforded these fossils, and in exploring some other localities in which beds of the same age appear. The results of these examinations are, *first*, the discovery of a few additional footmarks of one of the species of which specimens were sent last winter to the Geological Society. These new specimens are not however more distinctly marked than those formerly found at the same place. *Secondly*, the discovery, in a bed of coarse reddish shale immediately overlying the bed containing ichnolites, of some coprolitic bodies, probably of common origin with the footsteps. One of these coprolites, on analysis, was found to consist chiefly of carbonate of lime and argillaceous matter, with a considerable proportion of phosphate of lime, and traces of chlorine and organic matter. The figure of a well-marked specimen is given in the accompanying Plate, fig. 1. *Thirdly*, a confirmation of my previous belief of the carboniferous date of these beds with footmarks, by finding in them impressions of a species of *Neuropteris* common in our coal-formation, and fragments of *Sternbergia* and of a lycopodiaceous plant found in carboniferous beds, in various other parts of this province. *Fourthly*, having exposed larger surfaces of the sandstones on the banks of the French river of Tatmagouche than I had previously seen, I was struck with the vast abundance and great distinctness of the worm-tracks and casts of worm-holes, which cover the sur-

* *Vide* Quarterly Journal of Geol. Soc. vol. i. p. 326.

faces and penetrate the thickness of many of the beds. Many of these worm-tracks are marked with striæ, probably produced by the *setæ* of the worms. Beds similarly marked are seen in several places near Tatmagouche; and on the western side of the neighbouring promontory of Malagash, where the strata of the coal-formation have been thrown into a vertical position, large rippled and worm-tracked surfaces are exposed in the perpendicular face of the cliff. These ancient shores or banks, swarming with worms, were probably the feeding-grounds of the animals, a few of whose footmarks their surfaces have retained.

2. *Coniferous wood.*—At a particular level in the lower part of the newer coal-formation, calcareous petrifactions of coniferous wood are very abundant, in some instances appearing to have belonged to extensive rafts of drift-wood. A bed of sandstone, containing one of these petrified rafts, is well exposed on the shore between Cape Malagash and Wallace Harbour, and is there associated with a bed of gypsum, and a thin layer of limestone containing a few marine shells, of species found also in the lower carboniferous rocks; the whole forming a peculiar and unusual association of fossils, and affording the only instance that I have yet observed, of the occurrence of lower carboniferous shells at a level higher than that of the great coal-measures (as shown in the annexed section).

Section of Carboniferous Rocks at M'Kenzie's Mill near Wallace Harbour.



4. Grey sandstones with *Calamites* and trunks of *Coniferæ*.
3. Reddish clay and shales.
2. White granular gypsum.
1. Limestone with *Terebratulæ*, &c.

In the bed of coniferous wood at Malagash, the structure of many of the trunks has been very perfectly preserved; and slices exhibit very distinctly polygonal discs on the walls of the cells, like those of the genus *Araucaria*. On comparing slices from this locality with others of specimens from different parts of this country, which had not previously afforded very satisfactory results, it appears that the species of coniferous trees most abundantly found in the coal-formation of Pictou and Cumberland counties have the structure of the Araucarian pines. I have hitherto found no specimen exhibiting the discs of ordinary pines. On the weathered ends of trunks of Araucaria, in the sandstones at Pictou and near Wallace, rings of growth are often very apparent; and in some instances, the layers of yearly growth having separated in the progress of decay, as is often seen in recent wood, they have left vacant spaces, occupied in the fossils by calcareous spar. In a transverse slice the rings of growth can easily be seen with the naked eye. They do not exceed in width those of vigorous individuals of many recent coniferous species, but their limits are much less distinctly marked than in any Coniferæ now growing in this climate.

It is perhaps worthy of notice, that the alteration effected from the original structure of these calcareous fossils, consists merely in the filling up of the cavities of the cells with carbonate of lime, and in the carbonization of their walls. When fragments are exposed to the action of diluted hydrochloric acid, the calcareous matter is removed, and a flexible carbonaceous substance, retaining the form of the fragment, remains. This residual woody matter burns like touchwood, and leaves a very little white ash.

Coniferous wood is not unfrequent in the nodules of ironstone, included in the great coal-bed at the Albion mines. After preparing a great number of slices from these nodules, I have found them in general to contain wood showing coniferous structure, and in a few instances having the polygonal discs of the cells preserved. More rarely they afford fragments with the structure of Stigmaria. The wood contained in these nodules of ironstone is usually in the form of small rectangular pieces, similar to those which now result from the slow decay of coniferous wood on the surface of the ground; and it can scarcely be doubted that they are of the same nature with the less perfectly preserved fragments of similar form, which, in the state of mineral charcoal, abound in the surrounding coal. If this view of the nature of the mineral charcoal be correct, we learn from it, that the coal-beds containing these fragments were accumulated under circumstances which permitted the decay of great quantities of the most durable kinds of wood in the open air, and the partial dispersion of their remains. These conditions of decay and accumulation of vegetable matter are at present found only in wooded swamps occasionally overflowed by water.

3. *Stigmaria.*—At the extremity of Malagash Point the shore affords a section of rocks of the newer coal-formation, consisting of red and grey sandstone, shale, thin beds of limestone, and a small bed of coal. In one of the beds of shale I discovered a fossil stump of a tree, having connected with it roots with regular scars like *Stigmaria.* The trunk of the fossil was nearly at right angles with the plane of the containing beds, which are inclined at an angle of about 50°*. It was imbedded in coarse dark shale, and rooted in an indurated clay of the same colour. It was not more than one foot in height, being cut off by a bed of dark laminated shale, with impressions of fern leaves. A portion of one of the main roots, ten inches in length, was seen to be attached to the stump, and other portions, whose actual connexion could not be seen, appeared in the surrounding clay. All of these roots show, more or less distinctly, the regular scars and eccentric pith characteristic of Stigmaria. The whole fossil is a cast in dark indurated clay; the trunk however shows three well-defined parts. These are, first, an external coaly envelope or bark irregularly corrugated; secondly, the stony cast, whose surface shows rather indistinct, alternate, smooth and rough vertical stripes; and thirdly, an eccentric core, probably corresponding with that of the roots and having large transverse promi-

* I saw no other fossils in this bed, only a small part of which was exposed.

nences, which appear to have been connected with fibres or bundles of vessels, whose remains extend outward and downward through the outer part of the cast. I have sent with this paper specimens of the trunk and roots, and a sketch of the fossil as it appeared when *in situ* (fig. 2), trusting that, when examined by more competent botanists, they may give interesting information respecting the nature and affinities of Stigmaria. I also send a figure of a specimen of Stigmaria (fig. 3), seen in a bed below the roots above described, whose rootlets have penetrated two thin beds of sandstone and a bed of shale.

4. *Sternbergia.*—Fragments of plants of this genus are frequently found in the sandstones of the Pictou coal-field, usually in beds which also contain Calamites. They are in the state of stony casts, always invested with a thin bark or coating of lignite, whose outer surface is smooth and without transverse wrinkles. The inner surface of the coating of lignite has longitudinal ridges which adhere strongly to the surface of the transversely striated cast, and leave marks or small furrows when removed. Though specimens of this kind are not rare, and vary in diameter from half an inch to two and a half inches, I have seen none with any trace of roots, leaves or fruit, or even of a conical termination; all are cylindrical fragments, and so similar in their markings, that they may have belonged to one species. Transversely ridged stems, of a character very different from the above, are however occasionally found in the carboniferous beds of this province. These are stony casts, having irregular and often large transverse markings, and enclosed in a thick coat of lignite or fossil wood. In two specimens of the latter kind, transverse sections of the portion with structure, show cellular tissue apparently with medullary rays, and much resembling the wood of Coniferæ.

The fossils last mentioned are probably, as suggested by Mr. Dawes with reference to the British species of Sternbergia, casts of the pith of trees. It appears evident however, that the first-mentioned species (named I believe *Artisia approximata* in Mr. Lyell's list) was a plant having a very large pith and a comparatively thin woody envelope—in short a gigantic rush-like plant, perhaps leafless and nearly cylindrical, like some modern species of Juncus. To show the rush-like character of this curious fossil, I have sketched (fig. 4) a specimen from the Pictou coal-field, and a portion of the stem of a common species of Juncus from a swamp near Pictou; both showing the transverse structure of the pith, the marks left in it by the internal ridges of the envelope, and the smooth or longitudinally striated outer surface.

The above notices of some of the fossils of the coal-formation of Nova Scotia have been selected from the results of my late observations, from a belief that they may be serviceable in the elucidation of important geological questions now in process of discussion, and intimately connected with the palæontology of the coal period.

EXPLANATION OF PLATE VIII.

Fig. 1. Coprolite from the carboniferous sandstone of Nova Scotia.

2. Fossil trunk *in situ* having roots resembling Stigmaria (Malagash).
   1. Dark grey shale with fern leaves.
   2. Ditto coarse shale.
   3. Hardened dark-coloured clay.
   4. Limestone.
   a. Attached roots.
   b. Roots not attached.
   c. Bark.
   d. Ligneous surface.
   e. Core and attached fibres.

3. Stigmaria with rootlets penetrating sandstone and shale (Malagash).
   1. Shale.
   2. Sandstone.

4. Sternbergia from the Pictou coal-field, and recent *Juncus effusus* with part of the pith uncovered.
   a. Stony cast of pith.
   b. Coat of lignite.

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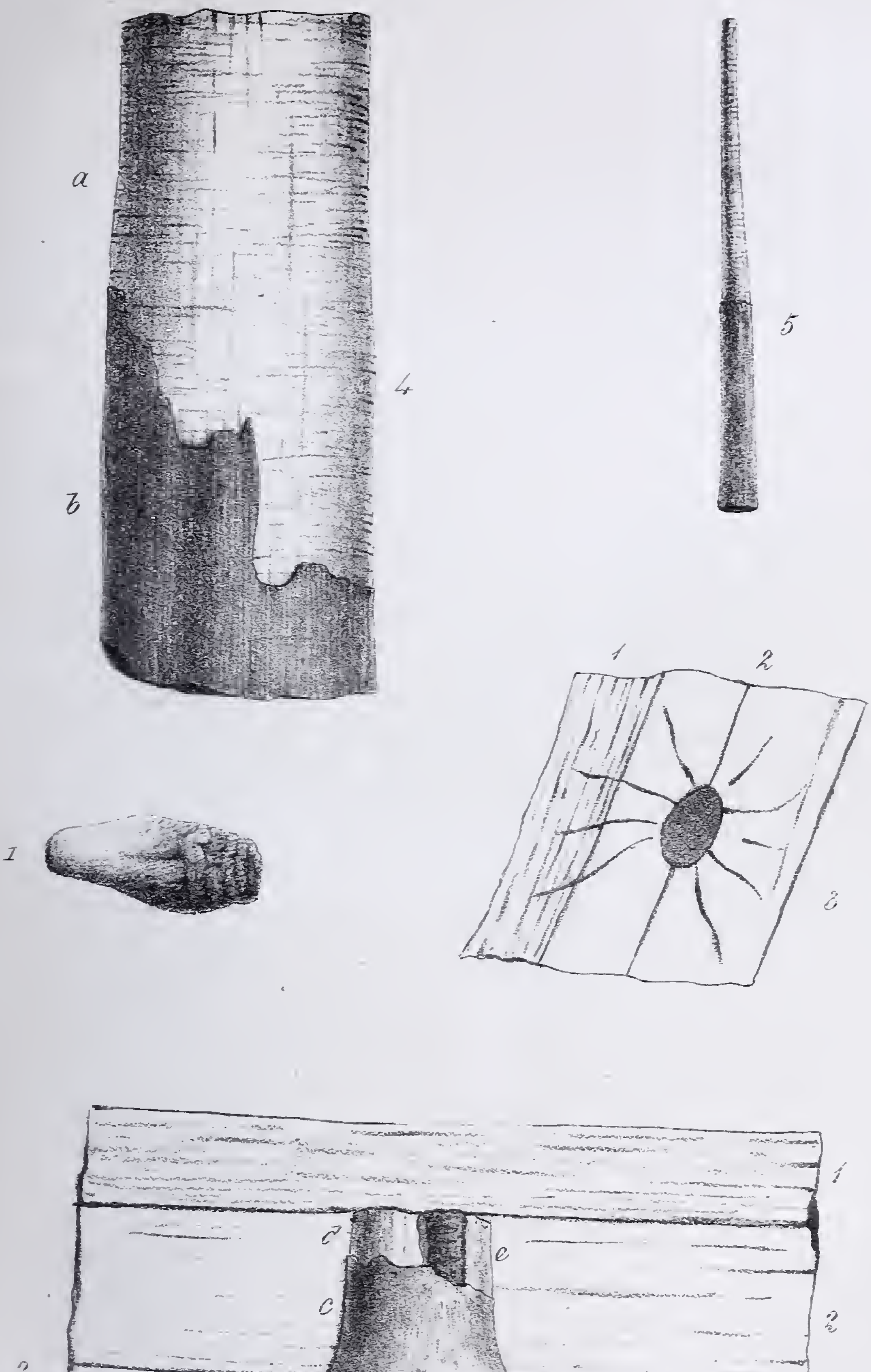
4. *Notes on the Fossil Plants communicated by Mr. Dawson from* Nova Scotia. By C. J. F. Bunbury, Esq., F.G.S.

The observations of Mr. Dawson on the fossil roots having the characters of Stigmaria are curious and important, as corroborating the statement communicated by Mr. Binney to the British Association in June 1845, respecting the tree with similarly marked roots which was discovered at St. Helens in Lancashire. Mr. Binney's statement, clear and positive as it seemed, has nevertheless been doubted by some of our most eminent geologists, who have believed the connexion of the supposed stem and roots to be merely apparent or accidental; and it is possible that similar doubts may be thrown on Mr. Dawson's observations. He appears however to have satisfied himself, that one of the Stigmaria-like specimens now before us did actually proceed in the manner of a root from the base of the stem. These specimens differ in some degree from the best-characterized forms of Stigmaria, their scars not having the distinctly circular and umbilicated form that is usual in that fossil: the appearance is as if the leaves or rootlets (whichever they may be) had not been disarticulated, but broken off abruptly; yet the symmetrical quincuncial arrangement of these scars, the presence of the excentric axis, and the general appearance of the fossils, leave no doubt that they are referable to the supposed genus *Stigmaria*. It has been urged, that the symmetrical arrangement of the scars is a fatal objection to the idea that these bodies were roots, which never emit their fibres with any degree of regularity; but, unless we suppose that Mr. Dawson has been deceived by appearances, this argument, drawn from the analogy of existing plants, must yield to the positive result of observation. It would not be the first instance in which the progress of discovery has revealed striking exceptions to what had been supposed general laws of structure. Exact and multiplied observations are certainly necessary to establish the existence of



Reeve, imp.

Fossils from the Nova-Scotia. Coal formation.

(Mr Dawson.)

such anomalies; but every new fact recorded by skilful observers, and bearing on a question of this kind, like that now communicated by Mr. Dawson, is of great value.

Whatever may be the case with regard to the Lancashire plant, I see no proof, either in Mr. Dawson's specimens, or in his drawing or description, that the fossil tree described by him was a *Sigillaria.* I can find no trace either of the regular flutings, or of the well-defined leaf-scars, characteristic of that genus. If indeed the Sigillariæ were Dicotyledonous trees, having the ordinary Exogenous mode of growth, it is clear that these superficial markings would be obliterated by the increase of the stem in diameter, and would disappear from the older parts of it, as happens in the Pines and Firs. But M. Adolphe Brongniart expressly states that the Sigillariæ present the same appearances, the same furrows and leaf-scars, in the lower parts of their stems as in the upper, and do not appear to have increased in diameter by successive additions to the exterior, after the manner of Exogens. It was partly on this ground, indeed, that he originally maintained that they could not be Dicotyledonous trees, but were of the nature of arborescent Ferns; and even after the examination of a specimen showing internal structure had induced him to admit that they belonged to the Exogenous class, he still dwelt on this peculiarity as removing them from the generality of plants of that class, and bringing them near to the Cycadeæ. In the figure which he has given of the base of a stem of Sigillaria* found at Anzin, we see in fact the furrows and vascular scars represented as very distinct and perfectly regular. It is possible that the various plants comprehended under the name of Sigillaria may differ in this respect; if not, we must admit that the Stigmariæ described by Mr. Dawson, though they might be roots, were not the roots of a Sigillaria.

Supposing it proved that the fossil called Stigmaria was really the root of a tree, (and although the question cannot yet be considered as definitively settled, I think that the positive and independent statements of two such experienced observers as Mr. Binney and Mr. Dawson give very great support to that opinion,) supposing this proved, there still remain some obscurities to be cleared up in regard to this singular production. In particular, what can be the nature of that strange dome-shaped centre, figured in the 'Fossil Flora,' vol. i. t. 31, and vol. ii. pref. p. xiii? Is it the base or stool of a trunk broken off near the root? The figure given in the preface to the second volume of the above-quoted work does not ill agree with this supposition; and it is possible that the "wrinkled appearance, with indistinct circular spots," which the upper surface is there said to have exhibited, may have been deceptive or accidental. Dr. Lindley, who seems to have been the first to hint† that Stigmaria might possibly be the root of Sigillaria, compares the dome-like centre and radiating arms of Stigmaria with the roots and base of the

* Hist. des Vég. Foss. vol. i. t. 160.
† Penny Cyclopædia, art. Coal Plants, published 1837.

stem of *Sigillaria pachyderma*, as figured in the 'Fossil Flora,' t. 54; and thus appears to suggest the same explanation of the nature of that anomalous dome as is here proposed. It may be observed, that in the figure last quoted the stem of *S. pachyderma* is represented as divided into several portions by apparent joints, the lowermost of which, occurring just above the roots, leaves the portion below it in a form very well adapted to the hypothesis in question; but I am not aware that anything similar has been noticed by others in any species of Sigillaria; and perhaps the appearance of articulations in that instance may be occasioned merely by the mineral structure of the stone of which the cast was composed.

The "transverse prominences," noticed by Mr. Dawson as proceeding from the "core" or excentric axis of the upright stem, are doubtless of the same nature with those which are often conspicuous on the surface of the vascular axis of Stigmaria, and which are represented in tab. 35 of the 'Fossil Flora.' They are the broken remains of vascular bundles which passed from the axis to the leaves or rootlets. A similar excentric vascular axis, with bundles of vessels proceeding from it to the bases of the leaves, is described by M. Ad. Brongniart in the only Sigillaria of which the internal structure has yet been ascertained; but, while the existence of the solid axis may very often be distinctly traced even in the stony casts of Stigmariæ, it does not appear to be so distinct in the Sigillariæ.

Before quitting the subject of these remarkable extinct forms of vegetable life, I may further observe, that the similarity of their vascular tissue to that of Ferns is not a sufficient proof of any real affinity to that tribe of plants, since Mr. Brown has ascertained that vessels of a similar structure ("*vasa scalariformia*") constitute the whole of the woody tissue of *Myzodendron**, a genus of parasitical flowering plants allied to the Misletoe, and totally dissimilar to Ferns.

Mr. Dawson's explanation of the nature of the so-called *Sternbergia* appears by far the most probable that has yet been proposed. The smooth outer coat observed by that gentleman (and of which I perceive traces in some English specimens) seems to afford an almost conclusive argument against M. Brongniart's opinion, that the transverse lines on the surface of the casts were the scars of fallen leaves. M. Brongniart appears to have been unaware of the existence of this smooth carbonized integument; it is slightly noticed by the authors of the 'Fossil Flora,' who however seem to regard it as adventitious, not belonging to the plant; but this, according to Mr. Dawson's observations, is by no means the case.

If a generic name be required for these bodies, that of *Artisia* ought certainly to be adopted in preference to *Sternbergia*, as the latter belongs to a genus of recent plants very different from these fossils.

In addition to the specimens described in Mr. Dawson's paper, that gentleman has sent a fragment of a somewhat anomalous appearance, of which he thus speaks in a letter to me:—

* Linnean Transactions, vol. xix. p. 231, note.

"I have sent a curious fragment picked up on the Joggins shore. It exhibits in one specimen two different forms of Sigillaria, usually I believe considered as different species. I have never seen another similar specimen, but think the association of the two forms in this piece cannot be accidental."

The specimen, now on the table, in fact exhibits on one side a sharp and distinct impression of the leaf-scars and other markings of a Sigillaria, apparently *S. scutellata* or a variety of it. The other side is plainly fluted, and has the appearance of a decorticated Sigillaria much rubbed and defaced, and with no distinct trace of the insertion of leaves. I am inclined however to believe that this singular diversity between the two sides of the specimen is accidental. It will be observed that that side on which the markings are sharp and distinct exhibits, *not* the original surface of the stem, but an impression of it, as is evident from the leaf-scars being situated in hollows or depressions, and from the narrow prominent ridges between them, where we should expect to find furrows: in short, all the markings are *in reverse*, as compared with what we see in perfect specimens of Sigillariæ. I conceive therefore that this cannot be really a portion of a stem exhibiting different characters on opposite sides. I am rather inclined to think that the clay of which this specimen is composed may have been moulded within the bark of a decayed stem of one Sigillaria, which gave it the simply fluted appearance, and, while yet soft and moist, may have received an impression on the other side from the external surface of a different stem. But I propose this explanation with much hesitation and doubt, as it is certainly very remarkable, under this supposition, that the ridges and furrows on the two opposite sides should so exactly correspond in direction.

February 4, 1846.

P. W. Barlow, Esq., F.R.S., and Dr. George Buist were elected Fellows, and M. F. Dubois de Montpereux of Neuchâtel a Foreign Member of the Society.

The following communications were read :—

1. *Observations upon* Sternbergiæ. By John S. Dawes, Esq., F.G.S.

This communication had reference to the remarks offered by Mr. Dawson in his memoir, read at the last Meeting of the Society, on Fossils from the Carboniferous Rocks of Nova Scotia. The author does not agree in the conclusion of Mr. Dawson, that herbaceous Endogens may sometimes have produced the columnar forms usually referred to the pith of coniferous and other large trees. He thinks that although the appearance in question may indicate that the fossil

is not that of a true Dicotyledon, it must still have been the interior cellular portion of an arborescent plant like Lepidodendron, the supposed bark being the vascular system or sheath surrounding the pith, which has adhered during decay to the medullary column, and sometimes become changed into coal. Examples of this condition were exhibited.

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2. *On the Tertiary Formations of the* Isle of Man. By the Rev. J. G. Cumming, M.A.

[This memoir forms the second part of the author's communication on the Geology of the Isle of Man. It is unavoidably postponed till the next number of the Journal.]

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

26TH FEBRUARY, 1846.

AWARD OF THE WOLLASTON MEDAL AND DONATION FUND.

AFTER the Reports* had been read, and before delivering the Medal to Dr. Fitton to forward to Mr. Lonsdale, the President said:—

GENTLEMEN,—You have been informed that the Council have awarded the Wollaston Palladium Medal and the proceeds of the Donation Fund for the present year to Mr. William Lonsdale, for his many valuable contributions to Geological science, and more especially for his descriptions of the Corals in the Silurian System and Devonian Rocks, for his late report in the first volume of our Journal on the Corals from the Tertiary formations of North America, and for his description of the Corals from the Palæozoic formations of Russia.

It would have been gratifying to you all, as I am sure it would have been to myself, to have seen our old and valued friend present in this room, to receive this acknowledgement of the high estimation in which he is held by that Society with which he was so long connected, and of the great value they attach to his important zoological and palæontological researches since his retirement. But, I am sorry to say, it is the state of his health which prevents his being here; and I fear there is too much reason to believe that his strength would scarcely have been equal to the exertion and excitement of coming to London on such an occasion. But I cannot help suspecting that another cause has not been wholly inoperative,—I mean that singular modesty, that unwillingness to bring himself forward, which, while it adds a grace and dignity to his character in the eyes of those who know him best, conceals from many his great accomplishments as a man of science, and his powerful and original mind. His absence therefore, in one sense, is not to be regretted; for it enables me to give utterance to expressions which I could not have ventured to use in his presence, from the certain knowledge that in doing so I should have given him pain.

Mr. Lonsdale was elected Curator of our Museum in 1829; he was well known by many to possess qualities that eminently fitted him for the office, and early in the spring of that year he had con-

* These Reports, &c. are inserted at the commencement of the present volume of the Proceedings and Journal.

tributed an important paper "On the Oolitic District of Bath," which is published in the third volume of the second series of our 'Transactions.' He was not at that time a Fellow of the Society, and the paper was communicated by Dr. Fitton, who has been requested by his friend to attend this day as his representative. In 1832 the Council, perceiving that the incessant labour and close confinement to which, notwithstanding every remonstrance on their part, he subjected himself in the service of the Society, imposed a duty upon him, the performance of which they hoped might renovate his health, by awarding to him the proceeds of the Donation Fund of that year, with a request that he would "in the ensuing summer continue his researches in the oolitic formations, and endeavour to detect the variations of mineral and zoological characters which mark that series in its range to the north of England." He complied with the request, and in the following December he communicated his observations in a paper entitled "Report of a Survey of the Oolitic Formations of Gloucestershire." He continued these researches in 1836, when he was again urged to travel for the sake of health; but although every one else, in all probability, would have found the results of his observations highly valuable, he did not himself consider them sufficiently so to lay them before the Society in any written communication: all that we have obtained of them is a donation he has just made to us of several sheets of the Ordnance Map, on which he has marked his observations during a series of oblique traverses, from the limit of his survey in 1832 to the Humber. His devotion to the affairs of the Society left him little leisure for work in the field, but his mind was always directed to researches in our Museum, especially in departments of palæontology, in which he knew that much was to be done. Many of those who had been working in the field, and submitted to him questions of difficulty in the determination of the fossils they had collected, must remember the valuable assistance he so willingly rendered them. In March 1840 he read a paper to us, which he entitled "Notes on the Age of the Limestones of South Devonshire," containing some new and curious results, the fruit of minute and careful examinations of the fossils in these rocks, and constituting a very important part of that body of evidence which led Professor Sedgwick and Sir R. Murchison to propose that division of the Palæozoic formations, which, adopting their term, we now class as the Devonian system.

In 1842 the enfeebled state of Mr. Lonsdale's health compelled him to resign the office in the Society, which for thirteen years he had filled with so much honour to himself and advantage to us. He retired to the south of Devonshire, devoting much time to the living corals on that coast; and some time afterwards removed to Bath, where he now resides. So far as his delicate health will allow, he in his retirement enjoys repose, but not inglorious ease; for he passes his time in philosophical researches which materially advance the science to which a great part of his active life had been devoted. The investigation of Fossil Polyparia is the subject to which his attention has been directed, they having long before been objects of

special interest to him; and in this department he has made himself unquestionably the highest authority in England. He has already embodied the results of his examination of fossil corals that have been submitted to him from various parts of the world in six separate communications, in which the determinations, whether generic or specific, have been deduced from a most diligent examination of the component structures, and where, with his characteristic fidelity and modesty, he has shown a careful regard to the labours of others, so far as their works were accessible to him. These communications have been,—1st, On Six Species from the Upper Cretaceous Beds of New Jersey; 2ndly, On Ten Species from the Miocene Tertiary Formations of North America; 3rdly, On Twenty-six Species from the Eocene Tertiary Formations of the same country; 4thly, On Six Species from the Palæozoic Formation of Van Diemen's Land, in the Appendix to Mr. Darwin's work on Volcanic Islands; 5thly, On the Corals of the Palæozoic Series of Australia and Van Diemen's Land, in the work of Mr. Strezlecki; and 6thly, On some characteristic Palæozoic Corals of Russia, in the Appendix to the first volume of Sir Roderick Murchison's great work on that country. His contributions to the works of Mr. Darwin and Mr. Strezlecki are peculiarly interesting, as being the first descriptions of corals from the palæozoic rocks of the southern hemisphere, some of which are at present peculiar to Australia.

Turning then to Dr. Fitton, the President continued,—I am happy to place in your hands, for your friend, this Medal, and this other part of the Award; for no one better knows, or is more capable of appreciating, the great scientific attainments of Mr. Lonsdale; nor can any one be more thoroughly acquainted with, or more justly estimate his high moral qualities.

On receiving the Medal Dr. Fitton replied on the part of Mr. Lonsdale:—

Sir,—I have been requested by Mr. Lonsdale, on receiving from your hands the Medal which the Council of the Society has awarded to him, to express to you and to the Society his deep sense of the honour which this mark of your approbation conveys; and if I were to act under the impulse of his own feeling, I believe that I should be called upon to add, that you have overrated his merit. But I cannot allow myself to go so far, even as the representative of my friend, since I firmly believe that the Society will have but one opinion upon this subject, and that the honour is most justly bestowed.

In the paper by which the Donation entrusted to us by Dr. Wollaston was announced (or rather his "*Bequest*," for it was one of the last acts of his life), the illustrious donor appears to have foreseen that in the allotment of its produce, personal attachment might possibly influence our judgement in favour of our officers who distinguish themselves in the discharge of their duties; for while he leaves to the Council the disposal of the fund, "in such a manner as shall appear conducive to the interests of the Society in particular, or of the Science of Geology in general," he has expressly added, that

"this latter application of it, to the purposes of science, will in his opinion be most creditable to the Council." I am therefore happy that circumstances, in a great measure accidental, have delayed the award of this Medal to Mr. Lonsdale till some years after his retirement from office; and that during that interval the new and additional claims arising from his productions have been such as to demand this decision as an act of strict judicial duty, obviously independent of the gratitude and attachment which all those who have known him justly entertain.

You have, Sir, clearly stated the specific grounds upon which the adjudication has been made; and I shall not presume to make any addition to a recital which comes with appropriate effect from the Chair: but having been so fortunate as to have had a share in the arrangements which first connected Mr. Lonsdale with this institution, and having since had full opportunities of observing the impress which his labours here received from his peculiar character and talents, during no less than thirteen years, I feel that I am called upon to express my conviction, that there never was an officer in the service of any public institution whose duties were fulfilled with greater efficiency or more beneficial results.

Of his skill and acquirements in some of the departments of natural science to which you have just referred, I am not qualified to judge; but I may perhaps be allowed to say, that in the range and soundness of his Geological views, and in exact acquaintance with the facts hitherto brought to light respecting the structure of the earth, few indeed of our number go beyond him. It was no wonder that with such a man to conduct the business of our Society, matters should go well; and for what was done during the years from 1829 to 1842, I refer to our 'Transactions,' and to the 'Proceedings' which record our daily progress. Who that is acquainted with the facts there stated will hesitate to say, that the suggestions of a man of Mr. Lonsdale's attainments, given at all times with cheerfulness and alacrity, and with a judgement which no difficulty or pressure of business could disturb, were of the greatest advantage to the inquirers whose papers were read at our meetings during that important period in our history?—I appeal with confidence to many of those by whom I am surrounded for the answer to this question; and I venture to say, that, without reference to his own specific publications, the services thus rendered by Mr. Lonsdale *to Geology*, while he seemed to be merely discharging his duties here, were of incalculable benefit to our science in the best sense of the word, and deserving of high reward.

Mr. Lonsdale's profession before we became acquainted with him had been that of a soldier. He brought with him into our service some of the best qualities of the military character,—singleness of purpose, the strongest sense of duty and subordination, with such devoted energy in the performance of whatever he undertook, as too often led him to exertions beyond his strength. His spirit "no labours could have tired," but the "frame of adamant" was wanting. Under these unsparing efforts his constitution at last broke down,

and he was obliged to resign his office, in such a state of health that little hope was entertained of his recovery. But he has revived; and restored to the power of moderate exertion, he has returned to the inquiries, some of which have this day obtained your approbation. He desires me to tell you, that while strength remains to him he will continue to pursue those inquiries. He bids me also to assure you, that his retirement will be cheered and enlightened by this proof that he is remembered here; and that you will have added essentially to the enjoyment of his remaining life. I have witnessed often what he suffered in our service. He will now feel that those days of toil and nights without repose,—the drops of life drawn from his very heart,—were not expended in vain.

After the other proceedings had been completed, and the Officers and Council elected, the President proceeded to address the meeting.

ANNIVERSARY ADDRESS OF THE PRESIDENT,

LEONARD HORNER, Esq., F.R.S. L. & E.

Gentlemen,—I congratulate you on the very satisfactory report which you have this day received from your Council on the present state of the Society. The number of our Fellows is greater than it was at the last Anniversary; and while we lament the loss of several of our Ordinary members, we have this consolation, that we do not number among them any of those known to the world as active promoters of our science; and that we have replaced our losses not only numerically, but with increased strength.

Although the active duties of a physician in great practice, rendered still more laborious to him by the large portion of his valuable time which he each day devoted to the relief of the sick poor, left little leisure to my old and excellent friend Dr. James MacDonnell of Belfast for the active pursuit of science, I cannot allow this occasion to pass without paying a tribute to his virtues, and to the ardent, I may say enthusiastic interest he took in the advancement of science, and especially in the great general views of Geology. His known attachment to the objects of our pursuit pointed him out in the early days of the Society as well-worthy of being enrolled in the list of its honorary members; and all who went to study the very interesting geological structure of the north of Ireland, and visited Belfast, were sure to receive from Dr. MacDonnell a most hospitable welcome, and much valuable information. He died last November, at the advanced age of 82; but, as I can testify by a letter I received from him a few weeks before his death, continuing a keen geologist to the last. Not many months previous he asked me to complete for him his series of our Transactions, looking forward to much enjoyment from reading them during the confinement to his room that

then appeared in prospect. In 1810 he made a short communication to this Society on the remarkable circumstance of nuts with their shells quite entire, yet filled with calcareous spar, found in a stratum of submarine peat in Belfast Lough; and in 1811, another notice on granite veins penetrating slate in the Mourne mountains in the County of Down.

Theodore Monticelli of Naples, the Foreign Member whom we have lost, was born in 1759, in the celebrated city of Brundusium, the modern Brindisi. He was educated in the Benedictine College at Rome, in which Chiaramonte, afterwards Pius VII., was then a professor, and where he made so much progress in his mathematical studies as to be able, while yet a very young man, to deliver a course of lectures on Natural Philosophy at Naples. In 1792 he was elected Professor of Ethics in the University there, but soon after, getting involved in the political troubles of that time, he was thrown into prison, and was confined six years. When he recovered his liberty in 1800 he went to Rome, where he was very kindly received by his old tutor, by that time raised to the Popedom; and some years afterwards he was nominated by Napoleon to be employed with others in the re-establishment of the University and Academy of Sciences of Naples, of which latter body he was in 1808 elected Perpetual Secretary.

He about this time directed his attention with great earnestness to the study of Vesuvius, forming a very rich collection of its products. He contributed many memoirs to the Academy, in which he described the active volcanic phænomena, which he watched with unceasing assiduity, their modern products, and those of the earlier history of that celebrated mountain. In 1813 he published an account of a great eruption of that year, which he dedicated to Sir Humphry Davy, with whom he was intimately acquainted; and Davy, during his residence at Naples some years afterwards, studied the structure and phænomena of Vesuvius under his guidance. Some years afterwards Monticelli published his 'Storia de' fenomeni osservati nelle eruzioni del Vesuvio,' and in 1825, in conjunction with Covelli, his 'Prodromo della Mineralogia Vesuviana,' which deservedly added to his reputation. In 1827 he was one of a committee appointed by the Academy to draw up a geological description of the island of Ischia; a work which was accomplished, and illustrated by several topographical and geological maps, but which has not yet been published. He also drew up for the Academy a memoir, which was printed in Latin, entitled 'Commentarius in agrum Puteolanum Camposque Flegræos.' He continued to the last an ardent cultivator of science, and died Secretary of the Academy, having filled the office thirty-seven years. He was alive during the Scientific Congress at Naples last September, but was too infirm to take a part in its proceedings. He was living in retirement at his favourite Pozzuoli, and in the month of October, when a few friends had assembled to celebrate his 87th birthday, he was seized at dinner with apoplexy, which terminated his existence.

The vacancy in our list of Foreign Members (so wisely restricted to a limited number) occasioned by the death of Signor Monticelli, you have worthily filled up by the election of M. Dubois de Montpereux of Neuchâtel, whose merits as a geologist are of the highest order, as he has fully shown in his great work on the Caucasus and the adjacent lands. But it is unnecessary for me to dwell on his just claims to the honour you have conferred on him, for you will find them ably set forth by Sir R. Murchison in his Anniversary Address of 1843*.

When we review the year that has passed, we have the satisfaction of feeling that the science we cultivate has made some important steps in advance, and that our Society maintains itself in undiminished vigour. Our pursuits become more and more objects of interest among all educated classes; and the works of some of our present most active Members have largely contributed to make geological inquiries attractive to those higher minds which recoil from vague unsubstantial speculations, and to the establishment of the sound philosophical views in the history of the earth's structure, which have raised Geology to the rank of an exact science in some of its most important fundamental truths.

We have had no meeting without some valuable communication, nor without instructive conversations on the subjects of the papers read. I regret that, in those discussions, our younger Members do not more frequently take a part; I do not doubt that they are influenced by a desire of rather listening to those they look up to as the established authorities, the great doctors of our laws, whose opinions we are accustomed to hear delivered to our great benefit on those occasions; but I am sure I speak the sentiments of all the senior Members when I say, that nothing would give them greater pleasure than to see those coming forward who are to constitute the future life and strength of the Society.

Library and Museum.

By the financial statements in the Council's report you have learned, that, after providing amply for the salaries of our officers and the other branches of ordinary expenditure, and after setting aside a considerable sum to be laid out on our Library, the Council will have at their disposal a large surplus, to be expended on publications, the way of all others by which the Society can render most service to the science we cultivate. The improvements which have been made in our Library during the last year, and the excellent classed Catalogue of our books and maps prepared by our Vice-Secretary, which may very shortly be in the possession of every Fellow, and the first five sheets of which are now on your table, will render that part of our establishment far more valuable than it has hitherto been, and will lay open treasures which few of the Fellows, probably, are aware that they possess.

* Proceedings of the Geol. Soc. iv. 108.

Excellent for the purposes of study as many parts of the collections in our Museum are at present, I do not doubt that before many months elapse they will be rendered still more valuable by the plans which the Council are now carrying into execution. Our specimens of the suite of formations, with the fossil contents of each, and of the various igneous rocks, in the British Isles, will be rendered more complete and accessible. The present arrangements for the foreign specimens we possess have proved inconvenient from the great extent of cabinet-room they occupy, and from the difficulty of keeping them in order without more attendants than we can afford to employ. The Council have not yet determined how our valuable collections illustrative of foreign geology may be most usefully arranged, consistent with the means we possess of preserving that degree of order which is indispensable for the due efficiency of any plan.

It is a part of the general scheme contemplated for the Museum to have a full Catalogue for each formation or principal group, of all the known fossils belonging to it, and of the lithological characters of its prevailing rocks, both British and foreign, distinguishing the specimens in the possession of the Society, and containing a list of all the works and memoirs that treat especially of the particular group; so that any one desirous of studying it may find in the rooms of the Society all the information that has been brought to light respecting the group. When each is successively completed, as far as it is possible by the means at the disposal of the Council, it is to be hoped that the Fellows will carefully examine these Catalogues, and not only hasten to supply the deficiencies, both in specimens and books, which they will in several departments most assuredly find, but will offer such suggestions for improvement as their several experience and opportunities may enable them. By such union of strength, and such active co-operation of the Fellows, far more will be accomplished than is possible by the unaided efforts of the most active Council and the most zealous officers.

You are probably all acquainted with the valuable work of Mr. Morris,—his 'Catalogue of British Fossils.' To have rendered that work complete, Mr. Morris would gladly, I have no doubt, have given a figure of each species; but it would have involved so great an outlay of capital, and enhanced the price so much, that no probable sale would ever have saved him from great pecuniary loss. To render this Catalague more useful in our Museum, I am now preparing, with the assistance of Mr. Morris, an illustrated copy of it, which we intend to present to the Society. We take the figures from every authentic source, by cutting up the plates of works in our own possession or contributed by those who are willing to assist us. I have this day laid upon the table for your inspection the first volume of our joint work, containing the *Conchifera Dimyaria*, *Conchifera Monomyaria*, *Rudistes* and *Brachiopoda*, as a specimen of what is intended; and it will be proceeded with as quickly as our opportunities will enable us.

Quarterly Journal of the Geological Society.

The establishment of our Quarterly Journal has unquestionably been the great feature in the past year. In the earlier days of the Society, and for a period of twenty years, our 'Transactions' were the only vehicle by which the papers read before us were communicated to the public. These, by their form and the nature of the illustrations, bore so heavily upon our finances, that a volume, or even a part of a volume, could be published only at distant intervals. To remedy, in some degree, the great evil of delay, the Proceedings were instituted in 1827; and they form a valuable record of the history of the Society, and of the progress of Geology for the last eighteen years. But in order to avoid an inconvenient and even injurious effect upon the sale of our Transactions, the Proceedings consisted of very brief abstracts of the papers, and being without illustrations, in many instances they conveyed a very imperfect idea of the nature and value of the memoir. But the great delay in the publication of memoirs in full, robbing authors in some instances of the honour of priority in discovery, the uncertainty when a paper that had been read would be published, and even the doubt that was sometimes raised whether it would ever appear, very materially diminished the usefulness of the Society, and, there is too much reason to believe, cooled the zeal of many of our Members, and forced them to send their memoirs elsewhere. In a progressive science like Geology, with so many active cultivators of it in every part of the world, rapidity of publication is of the first importance, that geologists may speedily know what has been done and is doing by others; thus affording information for their guidance, not only as to what their attention should be directed, but to save them from throwing away time and labour on what had been already done. A majority of papers may be perfectly well given in the octavo form, now that the great improvements of late years make it possible to have distinct and accurate illustrations by woodcuts, lithographs, and zincographs, upon a page of that size. By the adoption of a Journal appearing at regular periods and at short intervals, rapidity of publication is secured, and with the exception of papers requiring illustrations that can only be adequately given in a larger form, memoirs will in general appear within six months of their having been read at the meetings, and sometimes even more speedily.

But the institution of the Journal has enabled the Council to extend the usefulness of the Society by the addition of what is called the "Miscellaneous Part." The diffusion of the Society's publications must always be mainly among our own countrymen, among those interested in geological inquiries at home and in our colonies, and among our transatlantic brethren, speaking the same language as ourselves. Geology now embraces so wide a sphere of inquiry and is so actively cultivated in almost every part of the civilized world, that each year gives birth to works of the highest interest, greater in number than the most diligent can overtake, even among those whose whole time is devoted to the science, unless they con-

fine themselves to particular departments. Besides, we all know how difficult it is, even in London, to see the Transactions of foreign bodies, and especially scientific journals; and we surely, therefore, render a great service to the readers of our Journal, especially to our own countrymen, by serving up to them some of the more choice exotic fruits of the year,—some of the more valuable papers published in foreign countries; and by giving such notices of what is going on abroad as must be interesting to every geologist, together with lists of new books and memoirs. While we carefully adhere to our fundamental rule, applicable to this as well as to every other form of our publications, viz. that the Society, as a body, never expresses an opinion, I cannot imagine any possible way in which the Miscellaneous Part of the Journal can compromise either the character or proper dignity of the Society. To show how scrupulous the Council have been in the enforcement of the above rule, I may state, that when it was lately determined that the Journal was to be carried on on our own account, they instructed our Vice-Secretary, the Editor of the Journal, to abstain from the expression of his own, or any other contributor's individual opinion, in any analysis of a book or memoir he may insert in the Journal, lest, by implication, the Society might be understood to pass a judgement. Further, they have thought it advisable, for the same reason, to direct that no analysis of an English work be given, but simply an announcement of its contents.

I have been induced to make the preceding remarks on the Miscellaneous Part of the Journal, because I have heard opinions differing from those on which the Council have acted, expressed by some Fellows of the Society, for whose judgements I entertain great respect, who have said that it is a great innovation upon established custom, a departure from a sound principle, for a Society to publish, under its authority, anything beyond that which properly belongs to it as an integral part of its own proceedings. As the great purpose of our association is to promote the advancement of geological science, if a deviation from established custom will further that end, it is, in my opinion, both justifiable and expedient. If we review the history of the Society, we shall find a succession of such innovations upon established usages: the very institution of it was held by the then President of the Royal Society as a dangerous encroachment upon the province of that body; and under his influence one of our chief founders withdrew. The governments of societies, like the governments of nations, to be wise, must mark the effects and meet the demands of improved and extended knowledge; although a main prop had been removed, the new structure was not in the least shaken; its foundations were strengthened, and it has stood firm on that rock ever since; subject only to this change, that, like other rocks, by gradual elevatory movements it now occupies a higher level, to be, I trust, still further uplifted. The cultivators of other departments of science in London, following our example, instituted the Astronomical, the Zoological, the Geographical, and many other societies, all of which have proved that the productive and perfective

powers of the principle of the division of labour are as conspicuous in science as they are in manufactures. I am tempted to enumerate some more of our innovations, because the wisdom of them has been proved, not only in our own body, but by their having been adopted by other societies: the change of presidency from a virtually perpetual to a biennial office—the removal of all formality more than is necessary for the conduct of business at our ordinary meetings, by discussions and conversations on the papers read —the social assembling afterwards; neither the least agreeable nor the least useful part of our evenings. Our Proceedings were first published in November 1826; the first part of the Proceedings of the Royal Society is dated November 1830; and the first part of the *Comptes Rendus Hebdomadaires* of the Academy of Sciences of Paris bears the date of August 1835.

The Society's Transactions.

An idea has been entertained that the publication of our Transactions was to cease on the institution of the Journal. Such a proposal was never under the consideration of the Council, and it was always intended, that when a paper could only be advantageously given in quarto, that form should be adopted. As the best contradiction of the statement that had gone forth, your Council of the last year commenced the publication of the Seventh Volume of the Transactions with three valuable papers by Mr. Hopkins, Mr. Bain and Professor Owen.

But I must not allow you to suppose that all is prosperous with us; that nothing is wrong; or that all the Fellows of the Society may be perfectly satisfied with the efforts they have made to carry out our common object. It is my duty as your President to point out defects, as well as to put before you the favourable side of your affairs; and I am willing to hope, that it is only necessary to state what is wrong to secure an immediate remedy; especially when I know that a complete remedy is in the power of those who have made it necessary for me to say that all is not as it should be. I ascribe their faults of omission to a want of thought, and to nothing else.

From the number of copies of our Transactions and Journal still on hand, it is manifest that a very considerable number of the Fellows do not provide themselves with our publications. Now if our own Members do not patronize our works, to whom can we look with more confidence? We are strong only by united efforts; and when, in the case of the Journal especially, it is merely a question of a very small annual sum, for which, be it observed, full value is given in exchange, the many important memoirs we have published ought not to be suffered to lie dormant in our stores, when they might all be put in circulation if our own Members only were the purchasers.

Geological Survey of Great Britain and Ireland.

In his Anniversary Address of 1840, Dr. Buckland adverted to the recent establishment, by the Government of that time, of the Museum of Economic Geology. It not only received encouragement from their successors, but has been placed by them on a more enlarged and comprehensive plan. During the last year the Geological Survey of Great Britain and Ireland has been transferred from the direction of the Master General of the Ordnance to that of the Chief Commissioner of Her Majesty's Woods and Works; and that Survey and the Museum of Economic Geology are now united under one management. The establishment is supported by an annual parliamentary grant, which in the last session amounted to 8850*l.*, including the Museum of Economic Geology in Dublin; and large premises are about to be built by Government in a central part of the metropolis for the accommodation of the several departments, the extension of the Museum, and the accomplishment of other useful plans that are in contemplation. It is a reproach to former Governments that the formation of such an institution should have been left to recent times, in a country deriving so much wealth, importance and power from its mineral treasures.

When we consider the high qualifications of the officers selected by the Government for carrying out this scheme, we may look forward with confidence to their rendering important services to geological science, as well as to mining interests, the arts and manufactures. Sir Henry De la Beche is, as you are aware, the Director-general; and his indefatigable zeal and exertions, and above all the judgement shown by him in his recommendations of the other officers, cannot be too highly estimated. Mr. Andrew Ramsay is Director of the Survey of Great Britain; Captain James, of the Royal Engineers, is Director of that of Ireland; Professor Edward Forbes is Palæontologist, and Mr. Warrington Smyth, Mining Geologist for the United Kingdom; and there is reason to believe that Dr. Hooker will be appointed to the department of Botany *. Mr. John Phillips is engaged in the Survey of the North of England, and one laboratory of the Museum of Economic Geology is under the direction of Mr. Richard Phillips, one of the founders of this Society, and another under the direction of Dr. Lyon Playfair. There are besides several able officers in different departments.

You have this day had placed on your table a most valuable donation from Her Majesty's Chief Commissioner of Woods and Works, viz. twenty-four sheets of the Ordnance Map of England, coloured geologically, and about thirty large plates of Sections emanating from this establishment. They will go on publishing the Maps of the districts, and the Sections belonging to them, as the Survey of each is completed. They are to publish Memoirs drawn up by different persons engaged in the Survey, and two volumes of these are now in the press, one of them in a very advanced state.

* Dr. Hooker's appointment has since taken place.

They have begun a series of figures of fossil shells, drawn and engraved with the utmost care; and every plate will be sold separately, at a very moderate price.

For the last eighteen years it has been the custom for your President at each anniversary meeting to read an Address, the main feature of which has been a sketch of the progress of Geology during the preceding year. This plan was conceived and first carried into execution by our valued associate Dr. Fitton, who for many years has been, and, I am happy to say, still continues to be, one of the main supports of this Society. It was a plan calculated to be useful in many ways; and the future historian of the progress of Geology will find in the admirable addresses which have been printed, by the eminent individuals who during the above-mentioned period have occupied this chair, materials of the highest value. When I passed my eye over the list of my predecessors, I saw at once the difficulty of the task before me; and were it allowable to shrink from the performance of any of the duties which devolve upon your President, I would gladly have broken through the established custom, from the hopelessness of being able to execute the task to the satisfaction of my own mind; but I felt strongly that the custom ought to be maintained, even although the purpose should be imperfectly fulfilled.

The greater number of those who have hitherto delivered these anniversary addresses have belonged to the fortunate few who have been able to devote a great part of the best period of their lives almost exclusively to Geology. Such has not been my lot; I have had other duties to perform, which have left me but little leisure for the active pursuit of science; and all I can now attempt is to bring before you some of those topics that appear to me to possess most general interest, or to be steps in the progress of Geology, which have come under my notice in the limited sphere of reading and observation to which my opportunities have extended. When we consider the vast extent of the domain of Geology as it is now studied, that its fundamental principles are derived from many, indeed from almost all departments of natural history and physical science, it is not possible for any one, although he united the most comprehensive mind and varied attainments with indefatigable industry, to take even a rapid survey of the progress of Geology in a single year, using the term in its most enlarged sense. Even if we confine ourselves to the more important observations that have been made on the mineral structure of the earth, we shall find that to read merely the published accounts of the labours of the cultivators of this branch of science, now actively at work in all parts of the world, is beyond the power of almost any man, even if he had no other occupation. But even if such an herculean task were accomplished, the difficulty would still remain of compressing the general results into that space to which an address of this nature must necessarily be confined.

The Memoirs which were read in this room during the past year, to the conclusion of last session, have already been made known to all through the medium of our Journal; and I will not anticipate the contents of the number which will appear two months hence, and which, in all probability, will include all that have been read, and been ordered by the Council to be printed, up to the end of January; a rapidity of publication hitherto unexampled in the annals of the Society. I have no occasion therefore to do more than allude very briefly to what has been read within these walls, and I shall confine my observations almost entirely to what we have learned from other works published during the last year. Four of these, of pre-eminent interest, are the production of distinguished members of this Society—Sir Roderick Murchison, Mr. Lyell, Professor Owen, Major Cautley and Dr. Falconer. The 'Russia' of Sir R. Murchison and the 'America' of Mr. Lyell are each so rich in observations of the highest value, and embrace so many general views, that even a brief examination of the most interesting subjects they treat of made it impossible for me to refer to several other works of great interest, without exceeding all reasonable bounds. I have been the more inclined to extend my remarks on the work on Russia, because it is less likely, from its magnitude and price, to be in extensive circulation.

It is little more than six years since the publication of 'The Silurian System,' a work containing the results of several years of the most assiduous observation, conducted with the greatest ability. The appearance of this work will ever be held to form an epoch in geological science; and while it has secured to the author an imperishable name, it adds a lustre to this Society, in which he may be said to have been trained. It is so accurate in its details, that a very competent judge, who has trod, hammer in hand, over every part of the region, holds it to be the best piece of topographical geology in our language. Of the correctness of the descriptions I can speak from personal experience during the last summer, in a limited but somewhat complicated part of the country. But it is also a characteristic feature of all Sir R. Murchison's writings, that in the midst of his details, general views are never lost sight of. The principles of classification of the older of the palæozoic rocks laid down, and for the first time, in that work, have been proved by the subsequent researches, both of himself and of others, in distant lands, to be of the most extensive application. They threw a flood of light over many regions that had been explored by the best geologists, but were never before rightly understood; and the key once placed in their hands, geologists in all parts of the world were enabled to interpret and elucidate whole chapters in the earth's history, which revealed the most unexpected and important truths. The almost immediate general adoption of the term chosen by the author for his new classification of the rocks in question, was the most unequivocal proof that he had clearly established his case. It was only in 1836 that he announced his adoption of the term "Silurian System" for that group of distinct formations into which, after five years of the most patient observation, he had separated the trans-

ition rocks, the fossiliferous grauwacke, of the western parts of Herefordshire and Shropshire and the adjoining parts of Wales; and it is remarkable that so early as 1837, we find the "*Terrain Silurien*" recognised by the most experienced and distinguished of the French geologists. Indeed nothing can prove more strongly the accuracy of the principles upon which English geologists have separated the several groups of the stratified rocks in the British Isles, than the adoption by our brother-geologists of France not only of these divisions as normal types of formations, but of the English names by which they were originally distinguished. Thus, in the prospectus of the forthcoming '*Palæontologie Universelle*' of M. Alcide d'Orbigny, we find the *Etages Silurien*, *Devonien*, *Liassique*, *Bathonien*, *Oxfordien*, *Kimmeridgien* and *Portlandien*; and even the provincial term of *gault* is there canonized.

Having finished his work on Siluria, Sir R. Murchison did not claim any respite from the labours of the field, as our Proceedings and Transactions testify by several valuable communications; and in 1840, in conjunction with one of our most eminent foreign members, M. de Verneuil, and a young enterprising Russian geologist, Count Keyserling, he undertook the herculean task of exploring Russia in Europe, the Ural Mountains, and a considerable part of Sweden; mainly, as he tells us, "to test whether the British palæozoic classifications would be found equally true over a vast area, in which, since few or no igneous rocks were known, the history of succession might, he hoped, be read off in a very perfect and unbroken manner." The results of their joint labours have just been given to the public in two great and admirably illustrated volumes, which, from the variety and amount of the new and valuable information they contain, may justly be considered as the most important geological work that has appeared in this country, not only in the past year, but for a long period. The authors ask modestly, but very unnecessarily in my opinion, indulgence for inaccuracies of detail "in a first outline of regions which they traversed rapidly and partially examined." The local surveyor or engineer may perhaps discover inaccuracies of detail; but these, even if they exist, do not interfere with the broad general views, the great questions of geological interest, based on a most extensive series of observations, and described with clearness and perspicuity, which we find throughout these volumes.

Following the example of my predecessors, I propose to notice, in the first place, in the order of formations, such particulars relating to the sedimentary rocks as have most arrested my attention during the last year, contained in the works I have had an opportunity of examining with care. But before proceeding to that systematic review, it may be useful, for the reason I have already assigned, to give an outline of the great features in the geology of Russia in Europe and the eastern boundary of the Ural Mountains, described by Sir R. Murchison. And although he nowhere speaks in these volumes in the first person, but associates his fellow-travellers with him in all he tells us, if for the sake of brevity I more gene-

rally name him when I have occasion to refer to the authors, I hope I shall not be considered as detracting in the least degree from the merits of M. de Verneuil and Count Keyserling.

Geology of Russia.

Russia in Europe is "one huge depositary basin," encircled on the west and north by the granites of Sweden and Finland, and on the north-east, east and south-east by the chain of the Ural Mountains, which are mainly composed of plutonic and metamorphic rocks. It consists, to a very great extent, of a series of undulations, composed of incoherent clays and sands; but although in that unindurated state, not consisting of modern detritus, but being very ancient deposits that have undergone no consolidating process; for the whole of European Russia appears to have been exempted from igneous agency; no eruptions have tilted up the beds, but the elevatory forces, to which however it has been indubitably and repeatedly subjected, have raised the vast undulating plains *en masse*, without a break. The oscillations of the land having left the strike more or less horizontal, scarcely any traces of unconformability of strata of different ages are to be met with, and beds separated in time by vast intervals are in the same parallelism of juxtaposition as if they were the members of one group. Thus at the mouth of the Vaga, a tributary of the Dwina, about 150 miles south of Archangel, post-pliocene beds are seen resting conformably on limestones with Producti and Corals of the Permian rocks; and an observer unacquainted with fossils might view the two as parts of an unbroken series.

We have some most instructive examples of similarity of lithological characters between deposits of the most different ages, consequent perhaps in some degree upon that absence of consolidating processes to which I have alluded. A grit occurs in Sweden, described as a recomposed granite or granitic gneiss, which constitutes the base of the Silurian system in that country, that can scarcely be distinguished in mineral character from a tertiary grit in central France. Lower Silurian deposits charged with fossils common to the crystalline slaty rocks of other regions often occur as greensands and half-consolidated mud-like limestones. We have Silurian bituminous schists that resemble the hard beds of the Kimmeridge Clay. In one region a carboniferous limestone has all the characters of a soft tertiary deposit; in others, Devonian, Carboniferous and Permian rocks are not distinguishable from the younger secondary or even tertiary deposits of Western Europe; and even an oolitic rock of Miocene age cannot be distinguished from the Great Oolite of the Jurassic period.

These facts are most valuable, as showing that at all periods sedimentary rocks were formed, as they must now be forming, at the bottom of the sea, from the detritus of adjoining land, by the same agencies of disintegration as are now at work; and that then, as now, gravel, sand and mud were the forms which such detritus must have taken, to be afterwards compressed together, and consolidated by a variety of causes acting more or less intensely in different situations.

But Sir R. Murchison also observes, that the connexion between the character of the fossils and the nature of the matrix in which they are imbedded is more pointedly brought before the observer who ranges over the boundless tracts of Russia, than in any other country which he has examined. Notwithstanding the absence of violent dislocations, the various Russian formations, though horizontal, or so nearly so that they may be all considered conformable to each other, are as distinctly separable by their included remains, as in those typical and dislocated tracts where geologists first worked out their order. And these observations hold good in the newer as well as in the older deposits; thus, in the regions of the Volga, greensand, ironsand, chalk, and chalk marl occur, in which the same groups of fossils prevail as in the rocks of Britain and France, which hold the same relative place in geological succession; and pure white chalk, containing some characteristic organic remains, extends from the British Isles to the confines of Asia.

That so vast a tract of country, unlike most other parts of Europe, has been so little broken up locally by igneous eruptive rocks, may perhaps with great probability be ascribed to this, that a safety-valve was opened, an enormous crack or cleft was made on the east, by a subsidence of the country on the west, through which the pent-up elastic force and the molten matter escaped, and thus the high pressure was taken off from under the broad expanse. The Ural Mountains, bounding Russia in Europe on the east, are a comparatively narrow ridge, made up of igneous rocks and sedimentary palæozoic deposits; and through fractures in the latter the igneous rocks were erupted, after having produced in them those changes of structure which we call metamorphic, that is, having caused them to change their original characters, and assume a crystalline aspect; the force acting with such intensity as in many places to overturn the strata, and so invert the order of superposition on the flanks. But it has not been by one great fissure only that the igneous rocks have been erupted; "other parallel outbursts and upheavals have taken place along the same line at subsequent epochs;" and the authors show grounds for belief that the present form of these mountains was the result of more than one elevatory process, and that there was a period when, as a low ridge, they formed the western shore of a great continent to the east, that now called Siberia, and even at so recent a period as when that continent was inhabited by large quadrupeds closely allied to existing species. The Urals extend from Nova Zemlia to the Caspian, through nearly thirty degrees of latitude, in a direction nearly north and south, but sending off branches to the east and west at both extremities, one of which on the north-west, the Timan range, was first explored geologically by Count Keyserling in 1843; and in no part of this long line are they divided by any great transverse valleys, nor does their general altitude exceed from 2000 to 2500 feet. No parts of the authors' descriptions are of higher geological interest than those in which they speak of the Urals; and to some of the more striking features of that chain of mountains I shall afterwards more particularly refer.

The immediate substructure of the whole area of Russia in Europe is composed of the palæozoic rocks, which on the northern division are covered by sand, clay and blocks. A narrow band of Silurian deposits, the older members of that group, stretches along a great part of the shores of the Baltic, succeeded eastward by Devonian and Carboniferous formations, each occupying a vast extent of country, and lastly that highest member of the palæozoic order of strata to which the authors have applied the term "*Permian System*," the most widely-spread of all, occupying a region more than twice the size of the whole kingdom of France. Of the whole range of the secondary deposits between the Permian and the tertiary, two only have been met with, viz. that division of the oolitic series which includes the Oxford clay and its associated rocks, and in South Russia cretaceous rocks, including a white chalk very similar in mineral characters and zoological contents to that of England. The oolitic rocks overlie the Permian, but in detached masses, and with a surprising uniformity of character from the Icy Sea to the southern extremity of the Urals. There are besides, but in Southern Russia only, some limited tertiary districts, and of all ages, from Eocene to Pleistocene.

The most remarkable feature in the physical geography of the country described, and which may justly be said to be, in the words of the author, "one of the most singular features in the ancient condition of the surface of the globe which modern researches have brought to light," is that exhibited by the region around the Caspian; affording the most unequivocal proofs of great changes in the relative levels of the land and water, at a period geologically recent. Over a vast region a calcareo-argillaceous deposit exists in nearly horizontal stratification, abounding in freshwater shells and others analogous to, and to a great extent identical with species now living in the Caspian, attaining in some places a thickness of 300 feet; which appears to prove, that at the time it was deposited, there existed an inland sea, of brackish water, exceeding in size the present Mediterranean, and of which the present Caspian is the diminished relic. Of this remarkable deposit, designated "Steppe" and "Aralo-Caspian limestone" by the authors, I shall speak more particularly when I refer to the Tertiary formations.

This inland sea, although called by Sir R. Murchison a Mediterranean, he does not the less consider to have been entirely separated from the Western Ocean of that period, by a barrier, produced by the elevation of the marine tertiary beds of Miocene age, on which this Steppe limestone, in many places, is seen to repose. To affirm with certainty that the surface of this inland sea once stood at a higher level than that of the Caspian at the present day, and which, according to very careful measurements recently made by order of the Russian Government, is now proved to be 83.6 feet below the Black Sea, would require a most extensive series of local observations and levellings around the region occupied by the Steppe limestone, attended with very great difficulties. It is the opinion of some travellers who have carefully examined parts of this region,

that during the historic period, and within modern times, the surface of the Caspian has been diminishing, from the disproportion between the evaporation from so large a surface in that climate, and the sources of supply of water. Whatever portion of the land occupied by the Steppe limestone is now on a level with, and below the level of the Black Sea, may have been laid bare by this gradual lowering of the water of the Caspian; but whatever portion is above that level, and the greatest proportion of it is so, must, it is evident, have been upraised; and there is abundant proof of volcanic forces being in activity in that region to the present time. To endeavour to trace the direction of the vast body of water that must have been displaced by the upheaved land, as there could be no direct outlet to the ocean, would be an inquiry of great interest; for it can hardly be doubted that there must be evidence of a deluge or deluges having swept over a large portion of that part of Asia, and more especially if the elevatory forces acted suddenly.

As the leading features of the physical structure and the great geological divisions of the continent of North America are well known, I do not think it necessary to give any general outline of the country described by Mr. Lyell in his lately-published 'Travels'; but I shall have frequent occasion to refer to the information contained in that work on several points of great importance, in speaking of some of the additions in the past year to our knowledge of the great groups of rocks, and to our better acquaintance with questions of mineral structure, changes in the form of the land, and distribution of organic remains.

I shall now offer some remarks on the several great groups of formations, and shall begin with the lowest fossiliferous deposits.

Silurian Rocks.

It is certainly remarkable, considering the short time that has elapsed since Sir R. Murchison first proposed the separation of the lower beds of the palæozoic strata into one great series, that rocks which appear to be clearly made out to belong to the Silurian system should have been already recognised in so many regions remotely distant from each other. That they constitute a great part of Europe has been shown by many writers. The geologists of the United States and Mr. Lyell have told us how widely they are spread over the northern States of North America; and we learn from Captain Bayfield that they occur extensively all round Lake Huron; northward towards Hudson's Bay; along the northern side of the valley of the St. Lawrence, eastward to the strait of Belle Isle, and on the western coast of Newfoundland from that strait to its southern extremity. M. Alcide d'Orbigny has described them as extensively developed in South America; and from Mr. Darwin we learn that they probably exist in the Falkland Islands, adjoining the farthest

extremity of that continent. It is also more than probable, from the information we already possess, that they exist in Australia. The rocks were known, and had been partially described, but they were not understood; they were known mineralogically, and deposits separated by great intervals of time were classified together under the vague, uncertain, general term of grauwacke, or grauwacke slate, or clay-slate. The clear development of the system, and lucid descriptions of the normal types in the Silurian region of Britain, dispelled the obscurity that hung over the history of these ancient beds; and now geologists are at work in all countries, making out the great features of resemblance, and registering those variations in mineral and fossil contents, dependent on geographical position and other local causes, which are found to prevail more or less in all formations.

It appears to be now the opinion of those geologists who have most carefully and extensively studied the sedimentary rocks which contain the oldest forms and first traces of organic life, that from the highest beds of the Lower Silurian rocks to the lowest deposits in which organic remains have been found, there had been no great variation in the circumstances under which these beds were deposited, although there is evidence of a long duration of time, in which gradual changes in animal life took place, some species diminishing in numbers, others becoming extinct, others continuing to exist throughout the whole range, and a few appearing in the lower portion of these beds, which, from a marked general change of forms, are classified as the Upper Silurian rocks. This view you will see developed in the address delivered by Sir R. Murchison from this chair four years ago*, where he states, that the conventional line that had been drawn between the Lower Silurian and the Cambrian rocks beneath them had no longer any reference to strata identified by distinguishing organic remains, for the same fossils are found in strata on each side of that demarcation. He also stated on the same occasion, that "the zone of fossiliferous strata characterized by the Lower Silurian Orthidæ are the oldest beds in which organic life has been detected," and his belief that "many of the subjacent rocks, sometimes even when in the form of gneiss, mica schist, talc schist, chlorite slate, &c., are nothing but metamorphic rocks, in less altered parts of which the same typical fossils are observable." In his recent work on Russia he asks the questions, "Can we lay open the earliest vestiges of animal life, and amid palæozoic forms trace backwards primæval history to a protozoic type? Can we separate such protozoic strata from those which went before them, and were deposited *ere life had been breathed into the waters*†?" To the latter question I am disposed to answer, that the mere negative fact that we have not yet discovered traces of organized bodies in the lowest strata, certainly does not warrant the inference that no living thing had yet existed, or our saying, that *any strata* were deposited "ere life had been breathed into the waters." If these strata contain a particle of undoubted detrital matter, a grain of

* Proceedings of the Geol. Soc. vol. iii. p. 642.

† Russia and the Ural Mountains, &c. vol. i. p. 1.

rolled sand, they afford positive proof of the pre-existence of land and water, and atmospheric destructive agency to supply the materials of these strata, and the bed of a sea to receive them. Is it not highly improbable that this sea was untenanted? There must doubtless be a lowest sedimentary stratum, the materials of which must have been derived from land composed of non-sedimentary rocks. By "non-sedimentary" I mean a rock the formation of which may with the greatest probability be ascribed to igneous action. Whether it was granite, or any other form of igneous rock with which we are acquainted, we cannot tell; because of the great uncertainty as to how far the lowest sedimentary deposits have undergone changes by metamorphic action; but that silica and clay and very little lime entered into its composition is evident from the predominance of the two former earths in all the oldest strata, and the comparative rarity of lime.

But animal and vegetable life may have existed while the land that afforded the materials for the first sedimentary deposits was wholly composed of unstratified rocks. Nor is it necessary to have recourse to the obliteration by metamorphic action in all cases where there are no traces of organic remains. We have learned from the valuable report by Professor Edward Forbes of his researches in the Ægean Sea, that there are profound depths in which no animals and no vegetables seem capable of living; and thus, as there may be now, and probably are, deposits of vast thickness produced without organic bodies having ever lived in or upon them, in the profound depths of the Atlantic and Pacific Oceans, so is the absence of such remains in any stratum no proof, that when it was deposited there might not have existed above it a sea teeming with life. I cannot support this view better than by quoting what Professor Forbes says on the subject: "As in the sea there is a zero of vegetable life, so, we may fairly infer, is there one of animal life. All deposits formed below that zero will be void, or almost void, of organic contents. The greater part of the sea is far deeper than the point zero; consequently the greater part of deposits forming will be void of organic remains. Hence we have no right to infer that any sedimentary formation, in which we find few or no traces of animal life, was formed either before animals were created, or at a time when the sea was less prolific in life than it now is: it might have been formed in a very deep sea*."

The muddy waters of the Amazon stretch 300 miles into the Atlantic Ocean, and their sediment must be deposited in depths far below the zero of animal and vegetable life. Unless therefore portions of dead organisms be transported down steep slopes by submarine currents, from a shallower sea to those depths, and be mingled with the sediment, rocks must now be forming over the bottom of the Atlantic Ocean, which, when upraised in future ages, will exhibit as few traces of living bodies having existed when their component

* On the light thrown on Geology by submarine researches. Edin. Phil. Journ. April 1844.

parts were deposited as we can discover in the slates of Wales and of Westmoreland.

We have received as yet only a part of the results of the labours of Professor Forbes, and wait with impatience for his greater work; but what he has already made known to us of the changes that take place in organized bodies in different zones of depth, and in different states of sea-bottom, have so extensive a bearing upon many of the inferences hitherto drawn as to the ages of deposits, and to changes of climate from fossil contents, that some of our most established doctrines ought to be revised, and their soundness tested by their accordance or otherwise with these conditions. Others hypothetically anticipated that rocks might have been formed in depths unsuited to animal and vegetable life; but Professor Forbes was the first, I believe, to establish by actual observation that such is the fact as to depth, and also the first to show, as an element of geological reasoning, the connection that subsists between *the nature of the sea-bottom* (often changing on the same spot) and the living bodies it supports, and thus to demonstrate the existence of laws of the highest geological importance, and which must have prevailed throughout the whole range of formations.

Among the communications read before the Society since the last Anniversary, we have had two by Professor Sedgwick on the comparative classification of the fossiliferous strata of North Wales with the corresponding deposits of Cumberland, Westmoreland and Lancashire, both of them in continuation of his memoir read in November 1843. I will not attempt to give any abstract of the contents of these papers, because I could not do so, to any useful purpose, without extending my observations to an inconvenient length; but I recommend all who are desirous of acquiring an accurate knowledge of the geological topography of those parts of our island, and of becoming acquainted with many facts that throw light on that obscure and difficult part of geology, to study the memoirs themselves: those of 1843 and of March 1845 are published in the first volume of our Journal, and the last of them will appear in the number of next May*.

It is to Professor Sedgwick we are mainly indebted for the knowledge we possess of the geological structure of those parts of our island; it was he who first grappled with their very complicated and difficult conformation; for nearly twenty years he has been labouring to decipher their obscure and complex characters; and since the discovery of the Silurian key, he has been enabled to make out a clear and intelligible outline of the history of these regions, which, for a long time, geologists seemed to shrink from all attempts to understand. Let us hope that the learned author will soon gather together his scattered materials, and bring out a new edition of his work, with all the corrections and illustrations which his latest observations enable him to supply. When we have that volume, and can study it with the commentaries and the additional illustrations of accurate sections which we in part have, and may soon

* See *ante*, p. 106.

look forward to receive from Sir H. de la Beche and his fellow-labourers in the Geological Survey of Great Britain, we shall possess a very full and correct knowledge of these older sedimentary deposits, and the igneous rocks with which they are associated, and therefore of the most remote periods of geological history; and we may perhaps then indulge in a little excusable national vanity of possessing another standard with which the structure of extensive and distant regions of the earth will be compared, in addition to what we already have of many of the palæozoic and secondary formations.

A paper by Captain Bayfield read before us last April, and published in November in our Journal, gives us much important information on the Silurian rocks that prevail to a great extent in Canada; and we are indebted for a more accurate knowledge of the same class of rocks in the Isle of Man to the Rev. J. Cumming, in the first part of a description of that island, read last June.

We learn from the 'Geology of Russia,' that both in that country and in Scandinavia, a series of ancient deposits cover a great tract of country, which, in all their great features, and often in their minute characters, are identical with the Silurian series of the British Isles, and that they are equally divisible into two distinct groups, and are also overlaid by a true Devonian formation. In the central and southern parts of the continent of Sweden the Lower Silurian rocks only occur, but the adjoining islands of Oesel, Dago and Gothland are mainly composed of Upper Silurian rocks, affording even better types than Wenlock or Dudley. Describing the rocks near Katchkanar, on the eastern flank of the Urals, Sir R. Murchison says, "The banks of the river Is are composed for a considerable distance of white limestone, thickly tenanted by large Pentameri, some Trilobites, and shells which we hailed as true Silurians, and worthy of the very region of Caractacus. We were enchanted when we discovered myriads of them undistinguishable from the *Pentamerus Knightii*; so that seated on the grassy banks of the Is, we might for a moment have fancied ourselves in the meadows of the Lug at Aymestry." Of the Lower Silurian fossils of Russia a few only are absolutely identical with forms of the same age in the British Isles; but the mass of them is essentially the same as that of the main land of Scandinavia; which region being intermediate between England and Russia, is found to contain a considerable number of forms common to deposits occupying the same position in both the other countries. In the lowest part of the Lower Silurian rocks that skirt the southern shores of the Baltic, a grit occurs so abounding in a minute shell, the Ungulite or *Obolus* (which has a great affinity to the *Lingula*), as to form entire beds. Here we have a parallel to those beds in the Silurian series of the British Isles, abounding so copiously in the *Lingula attenuata*. It is also a parallel to beds occurring at a far more distant point, on the opposite side of the Atlantic. Mr. Lyell, in describing the Potsdam sandstone, the lowest member of the Silurian series in North America, as it occurs on Lake Champlain, says, "In many places this most ancient of the fossiliferous rocks of New York is divided into laminæ by the

remains of innumerable shells of the genus *Lingula*. They are in such profusion as to form black seams like mica, for which they were at first mistaken. It is highly interesting, that in this lowest fossiliferous bed, one of its commonest organic remains should belong to a living genus, and that its form should come very near to species now existing. Throughout so vast a series of ages has Nature worked upon the same model in the organic world!"

The Silurian system of the northern countries of Europe is, as a whole, closely analogous to that of Great Britain; and it proves that wherever the sediments of the same age in the two regions resemble each other in lithological texture, such similarity is accompanied by a close approximation and frequent identity in the associated organic remains. When the fossils from the Silurian beds of Northern Europe were compared, Mr. Lyell informs us, by M. de Verneuil with those brought by him from America, there was a great distinctness; but the representation of generic forms, whether in the organic remains of the Upper or Lower Silurian strata, was most clear and satisfactory. The geologists of New York make three distinct groups in the Lower Silurian, and four distinct groups in the Upper Silurian series of that country, and Mr. Lyell is of opinion that these divisions are based on sound principles; that is, on mixed geographical, lithological and palæontological considerations; the analogy of European geology teaching us that minor subdivisions, however useful and important within certain limits, are never applicable to countries extremely remote from each other or to areas of indefinite extent. The Silurian rocks are developed in North America on a great scale, and like those of Russia are little disturbed from their original horizontality, making the order of their relative positions clear and unequivocal in both countries. In lithological characters there is a considerable resemblance on both sides of the Atlantic—mudstones, sandstones and limestones prevailing. In America however there is an intercalated group in the Upper Silurian system, to which nothing analogous has yet been observed in Europe, as far as I am aware. It consists of red, green and bluish marls, with beds of gypsum and occasional salt-springs, the whole being from 800 to 1000 feet thick, and undistinguishable from parts of the Upper New Red Sandstone or Trias of Europe. A similar intercalated group of red and green argillaceous marls with gypsum and salt-springs is met with in the middle of the Devonian group in Russia. This occurrence of gypsum and muriate of soda associated together in the older strata as they are in the Pliocene, as well as in many intermediate periods, is a remarkable circumstance; and it would be an investigation well-deserving the joint labours of the chemist and the geologist, to endeavour to account for the origin of these chemical formations.

With regard to the fossil contents of the Silurian beds of North America, it appears that "while some of the species agree, the majority of them are not identical with those found in strata which are their equivalents in age and position on the other side of the Atlantic. Some fossils which are identical, such as *Atrypa affinis*,

Leptæna depressa and *Leptæna euglypha*, are precisely those shells which have a great vertical and horizontal range in Europe—species which were capable of surviving many successive changes in the earth's surface, and for the same reason enjoyed, at certain periods, a wide geographical range. It has been usually affirmed that in the rocks older than the carboniferous, the fossil fauna in different parts of the globe was almost everywhere the same; but Mr. Lyell adds, "that however close the general analogy of forms may be, there is evidence in the Silurian rocks of North America of the same law of variation in space as now prevails in the living creation:" and in another place he states, that with regard to the proportion of species common to the Silurian beds of Europe and America, whether of the upper or lower division, he can confidently affirm that it is not greater than a naturalist would have anticipated, from the analogy of the laws governing the distribution of living invertebrate animals.

While the remains of fucoid plants are met with abundantly in the Silurian rocks of Europe and in the lowest members of the series, I am not aware that any vestiges of land plants have yet been discovered in them. Sir R. Murchison says, that in the older palæozoic rocks of Russia he met with no signs of terrestrial fossil vegetables. Fucoids are plentifully distributed through every part of the series in North America; and Mr. Lyell also states, that in the Hamilton group, which corresponds in many of its fossils with the Ludlow rocks, and which, singularly enough, is met with in the neighbourhood of Ludlowville, remains of plants allied to Lepidodendron have been found associated with fossils agreeing perfectly with European Upper Silurian types; and that other plants allied to these, and ferns, have been met with in the lowest Devonian strata of New York, associated with fossil shells closely allied to the Silurian. Thus we have additional proof, if any were wanting, of the existence of dry land at the time of the deposition of these Silurian beds.

Devonian Rocks.

The Silurian rocks of Russia in Europe are covered conformably by deposits, the identity of which with the Devonian or Old Red Sandstone series of the British Isles, Sir R. Murchison and his companions clearly made out. They extend over an area of not less than 150,000 square miles, a superficies greater by nearly one-third than that of Great Britain and Ireland together. This monotony of feature over so vast a space is even greatly surpassed by the Permian rocks; and when it is considered that this uniformity is combined with a stratification rarely deviating from the horizontal, never thrown up into natural sections, and that the investigation of them can only be carried on where the beds are exposed in the banks of rivers, geologists can appreciate the tedium and labour of exploring such a country, and cannot too highly praise the patience and perseverance of Sir R. Murchison and his fellow-travellers.

Although recognized by a remarkable degree of identity in fossil contents, and especially in regard to ichthyolites, as a deposit

of the same age as the old red sandstone in our own country, it is lithologically very different in most places. Sometimes it is made up of numerous alternations of flat-bedded, light yellowish limestones, often so impregnated with magnesia as to be scarcely distinguishable from some of the magnesian limestones of England, or the Zechstein of Thuringia; at other times it is composed of red and green flags and marls; and, on the flanks of the Urals, this series is represented by black and calcareous slaty masses. Moreover, it is comparatively rare as a red sandstone. But the fishes and shells the beds contain soon rectify the mistake as to the true position of these rocks, into which their mineral aspect alone might lead the most experienced geologist, should he not have an opportunity of seeing them reposing on true Silurian rocks and covered by carboniferous strata. In regard to the evidence from fossil contents, it is so complete in these Russian deposits as not only to establish their own position, but to corroborate the soundness of the reasoning which unites the old red sandstone of Scotland with the slaty limestones and schists of Devonshire and the Continent; for they contain the characteristic fishes of the former and the mollusks of the latter. The examination of Russia, Sir R. Murchison further observes, has afforded numberless proofs that the ichthyolites and mollusks which in Western Europe are separately peculiar to smaller detached basins, were there inhabitants of many parts of the same great sea. Of the known Russian ichthyolites, two-thirds are specifically the same as those of the same epoch in Great Britain.

The neighbourhood of Dörpat in Lithuania is a very remarkable locality for the ichthyolites of this age; they are there met with of so gigantic a size, that they were supposed to belong to Saurians, until the closer examinations of Professor Asmus of Dörpat, M. Agassiz and Professor Owen disclosed their true nature. A note by Professor Owen in the Appendix to the 'Geology of Russia' is highly instructive, as showing the great importance of an examination of the internal structure of the substance of fossil teeth by the microscope, in determining the classes of animals to which they have belonged. He points out, by a striking illustration, how the microscopic labours of the philosopher in his closet may have the most important effect on questions that appear to be far remote from the subject of his inquiry. Had the teeth under consideration continued to be held to belong to Saurians, the matrix in which they are imbedded having a close resemblance in mineral character to magnesian limestone, or to members of the new red sandstone series, borings for coal might have been carried on in many parts of Russia, involving vast losses; but the teeth having been proved to belong to a class of fishes that are characteristic of the old red sandstone, all expectations of finding profitable seams of coal are known to be vain.

If we now cross the Atlantic with Mr. Lyell, and visit the Silurian region of North America, we find that series of rocks covered by others having characters corresponding with those of the Devonian group in Europe. The rocks of the Appalachian chain con-

sist of deposits of the Silurian, Devonian and Carboniferous periods. A deposit called by the American geologists the Waverley sandstone, which Mr. Lyell is of opinion corresponds with the old red sandstone of Europe, intervenes in the state of New York between the coal-beds and the Upper Silurian groups, in strata of considerable thickness. On the western side of the Alleghanies, at Portsmouth on the Ohio, the same formation also occurs, but greatly diminished in thickness, some of the subordinate beds being reduced to a very thin slate, others entirely lost, conformably with what is observed in other sandstones and associated slates and shales in that country, viz. by a gradual thinning of the beds as they extend westward, and as they become more distant from that great eastern continent, now sunk beneath the waters of the Atlantic, from which the materials composing them must have been derived.

Our knowledge of the old red sandstone or Devonian group has been much advanced by the Monograph of the fishes of that series of deposits by M. Agassiz, which has just been completed; a work of the highest merit, in which the skill with which the anatomy of the singular forms of that earliest creation of fishes is worked out is quite admirable, and which also contains many highly important general views. This work was undertaken at the request, and has been carried out by the assistance, of the British Association, and is one of the many valuable gifts for which science is indebted to that body.

The history of the old red sandstone supplies a useful lesson to geologists, by showing them the danger of coming to hasty conclusions, and founding generalizations, on negative evidence. The formation itself was long supposed to be confined to a limited portion of England; it is now known to extend over large districts in the British Isles and on the continent of Europe. It is most extensively developed in the northern and western parts of the United States, as may be seen by inspecting Mr. Lyell's Map; and we learn from Captain Bayfield that a sandstone which prevails greatly in Upper Canada, and which may be traced all round Lake Superior, resting on granite, appears to be of the same age as the old red sandstone, or Upper Silurian; and he also observed in the district of Gaspé, at the south entrance of the river St. Lawrence, a calcareous sandstone with Devonian characters. It appears too from the work of Mr. Strzelecki on New South Wales and Van Diemen's Land, published last year, that the greater part of the palæozoic rocks he examined in Australia and Tasmania are the equivalents of the Devonian series. In like manner this bed was long held to be barren of organic remains; Sir Henry de la Beche, in the third edition of his 'Manual of Geology' published in 1833, which was no doubt brought up close to all that was known at that time, says, "Few organic remains have been discovered in that rock." When M. Agassiz, in 1833, began the publication of his 'History of Fossil Fishes,' he knew of none older than the coal-measures, and only a small number in them; and he tells us that when he first learned that fishes had been discovered in the old red sandstone, during

his visit to Scotland in 1834, not more than four species were known. Five years afterwards, when Sir R. Murchison published his 'Silurian System,' ten genera and seventeen species of fishes, and fifteen genera and twenty-three species of mollusca are enumerated by him as belonging to the middle and lower Devonian beds. In the recent work on Russia, M. de Verneuil enumerates forty-six species of fishes and sixty-six species of mollusca, which he and his fellow-travellers found in the same group in that country. M. Agassiz, in his 'Monograph of the Fishes of the Devonian System,' raises the number of genera to forty-three, and of species to 105, belonging to six or seven families; and he tells us that Monte Bolca itself, hitherto reported to be the locality of all others most rich in species of fossil fishes, does not contain a greater number; adding, that as only a comparatively small portion of the rocks of this system has been examined, many additions may be expected. M. Agassiz is shortly going, it is said, to North America, where he will very likely discover many new forms. It is gratifying to find him ascribing the main success of his researches in this field "aux recherches persévérantes et au zèle infatigable des géologues Anglais."

But not only is there this great variety of genera and species, but the number of individuals found in some localities is immense. Thus in some parts of Russia there are breccias almost wholly composed of the scales and plates of the Asterolepis, and the remains of the Pterichthys are so abundant in the geodes of Lethen Bar in Nairnshire as to have been collected in cart-loads. But our wonder is not alone excited by the great variety and number of vertebrate animals of a high organization in strata so very low in the order of formations; there are many most remarkable features in the history of this early part of the animal creation which the researches of M. Agassiz have brought to light; for these however I must refer you to the work itself.

M. Agassiz, in speaking of the lowest beds in which the remains of fishes have been found, makes the following important observations on the probability of their existing in still lower beds:—"If we have not yet been able to recognize remains of fishes below the Lower Ludlow rocks, I do not think that we ought from that to conclude that fishes do not exist even in the oldest of the fossiliferous beds; for their extraordinary abundance in the Devonian series, and the distinct recognition of them in certain Silurian beds, where, it is true, they are but imperfectly preserved, sufficiently indicates that on its first appearance that class of animals was contemporary with the development of the types of all the classes of invertebrate animals."

Mr. Lyell states that the lowest rock in which ichthyolites have been traced in America is the Clinton group, which may be considered the bottom of the Upper, or top of the Lower Silurian series. Ichthyolites have recently been found in the Wenlock shale; another step in descending order, and so far in support of M. Agassiz's views.

The Carboniferous Series.

Although rocks of this age cover a great extent of country in European Russia, extending over a tract equally vast in horizontal extension with that occupied by the Devonian series, there are few places, except in the coal-field of the Donetz in the south, where the coal-seams are more than a few inches in thickness; and where they are thicker, they are so poor in quality as to be rarely worth working. The great coal-fields of England, France, Belgium and America have no well-marked equivalents there, nearly the whole of the coal-beds in the empire being, like those of Ireland and the coal-field on the banks of the Tweed, included in the lower members of the system; which, with the sandstones, shales and marls, are the equivalents of our mountain limestone, as is proved by the identity of a large series of fossils. From a section of the works at Lissitchia-Balka on the river Donetz, we learn that in a depth of 900 feet there are twelve seams of coal, the united thickness of which amounts to thirty feet; they are associated with sandstones, grits and shales; and eight beds of limestone are intercalated (containing, from the uppermost to the lowest, marine shells), the united thickness of which is fifty feet, three of the beds of limestone resting directly on the coal. Many of the forms of Equisetacea, Calamites, Sigillariæ and Ferns are of the same species as those of the west of Europe; and the carboniferous fauna of Russia contains numerous forms identical with those in the same class of rocks in the British Isles.

A glance at the Geological Map which accompanies Mr. Lyell's 'Travels,' shows the enormous development of the coal series in the territory of the United States, and that it occupies no inconsiderable space in Nova Scotia and New Brunswick. We learn from the report of Mr. Logan, on the Geology of Canada, which I shall presently refer to, that a great coal-field covers nearly the whole of New Brunswick, a considerable part of Nova Scotia, Cape Breton Island and the south-west corner of Newfoundland. The greater part of the carboniferous series in North America belongs to the upper portion, and not only abounds with numerous and thick beds of coal, but, on the western side of the Alleghanies especially, they are so little disturbed, and lie so nearly horizontal, that the coal is quite easy of access; and where the strata are intersected by rivers, it can be obtained with little trouble or expense. The great coal-field of Pennsylvania, Virginia and Ohio extends continuously from north-east to south-west for a distance of 720 miles, its breadth being in some places 180 miles*. That extending over parts of Il-

* On the 17th of March I received a letter from Mr. Lyell, dated the 16th of February at Tuscaloosa in Alabama, containing a notice on the Alabama coal-field, and which was read at the Geological Society on the 25th of March. He states that he had been examining three coal-fields, the existence of which was unknown to him when he compiled his Map in 1844. They occur near Tuscaloosa, in the centre of Alabama, more than 100 miles farther south in a direct line than the southern limit which he had assigned to the Appalachian coal-field, and are situated on the Tombecbee, Great Warrior, and Cahawba rivers. That on the Great Warrior river has been found by Professor Brumby of the University of Tusca-

linois, Indiana and Kentucky is not much inferior in dimensions to the whole of England, and consists of horizontal strata, with numerous rich seams of bituminous coal. Another carboniferous deposit, 170 miles by 100, lies farther to the north, between Lakes Michigan and Huron. I may give the following as an example of the almost boundless resources of fuel which this country affords. At Brownsville, on the Ohio, there is a seam ten feet thick of good bituminous coal, commonly called the Pittsburg seam, which may be followed the whole way to Pittsburg, fifty miles distant. "The boundaries of this seam have been determined with considerable accuracy by the Professors Rogers in Pennsylvania, Virginia and Ohio, and they have found the elliptical area which it occupies to be 225 miles in its longest diameter, while its maximum breadth is about 100 miles, giving a superficial extent of about 14,000 square miles."

Mr. Lyell states that at Blossberg in Pennsylvania he was much struck with the surprising analogy of the coal-measures to those of Europe in mineral and fossil characters. The same grits or sandstones are found as those used for building near Edinburgh and Newcastle; similar black shales occur, often bituminous, with the leaves of ferns spread out as in a herbarium, the species being for the most part identical with British fossil plants; there are seams of good bituminous coal, some a few inches, others several yards in thickness associated with beds and nodules of clay ironstone; and the whole series rests on a coarse grit and conglomerate containing quartz pebbles, very like our millstone grit. The same similarity of mineral and fossil characters to European coal-measures is found to prevail throughout North America. That remarkable circumstance of the very general occurrence of a sandy clay abounding in Stigmariæ beneath the seams of coal, observed in the Welsh and other coal-fields of Britain, is also found to prevail in those of North America. Mr. Lyell saw numerous instances of this; thus, at Pottsville in Pennsylvania, there are thirteen seams of anthracitic coal (true bituminous coal supposed to be altered by metamorphic action, a subject to which I shall allude hereafter), several of them from eight to ten feet thick, and in a vertical position: on the side which had been the roof of the coal, consisting of shales, he observed numerous ferns with stems of Sigillaria, Lepidodendron and Calamites; on the other side, that which had once been the floor, he found an underclay with numerous Stigmariæ, often several yards, and even in some cases as much as thirty feet long, with their leaves or rootlets attached.

Theories of the Formation of Coal.

It is scarcely possible to visit a coal-field, or to read the description of one, without being led to theorize on its mode of formation. The origin of coal has long been a subject of great difficulty, nor

loosa, to be no less than ninety miles long from north-east to south-west, with a breadth of from thirty to forty miles. These coal-fields are portions of the great Appalachian coal-field, with the same mineral and palæontological characters. Mr. Lyell promises a more detailed account of his observations.—*April* 3, 1846.

has any theory been yet advanced with which it has been possible to reconcile all the appearances which the coal-measures exhibit, all the variety of forms in which coal is found. Indeed the more closely we examine the phænomena, the more do we feel the distance we are from a satisfactory explanation of them. According to some geologists, coal-seams and their accompanying strata are accumulations of land plants and stony detritus carried down by rivers into estuaries, and deposited in the sea, where the vegetable matter undergoes changes that convert it into coal. Others are of opinion that coal is the altered residuum of trees and smaller plants that have grown on the spot where we now find them; that the forests were submerged and covered by detrital matter, which was upraised to form a foundation and a soil for another forest, to be in its turn submerged and converted into coal, and that thus the alternations which the vertical section of a coal-field exhibits are to be accounted for.

In the works of the last year to which I have chiefly referred, we find the former theory maintained by Sir R. Murchison as most generally applicable; Mr. Lyell is more inclined to adopt the latter. Sir R. Murchison dwells upon the facts of the alternations of coal with limestones containing marine remains, which are so frequently met with in most countries where coal-fields prevail; and as a striking instance of this, he refers to the Donetz coal-field which I have already alluded to. A remarkable example of a similar kind, occurring in Maryland, is mentioned by Mr. Lyell. At Frostburg a black shale ten or twelve feet thick, full of marine shells, rests on a seam of coal about three feet thick, and 300 feet below the principal seam of coal in that place. The shells are referable to no less than seventeen species, and some of them are identical with, and almost all the rest have a near affinity to species found in the Glasgow and other coal-measures.

The theory which refers the coal to trees and plants which have grown on the spot where it now rests is illustrated by Mr. Lyell by observations he made in Nova Scotia, on the south shore of the Bay of Fundy, at a place called "The Joggins." He states that there is a range of perpendicular cliffs composed of regular coal-measures, inclined at an angle between 24 and 30 degrees, whose united thickness is between four and five miles. About nineteen seams of coal occur in the series, and they vary from two inches to four feet in thickness. The beds are quite undisturbed, save that they have been bodily moved from the horizontal position in which they must have been deposited to that inclination they now have. In these coal-beds, at more than ten distinct levels, are stems of trees, in positions at right angles to the planes of stratification, that is, which must have stood upright when the coal-measures were horizontal. No part of the original plant is preserved, except the bark, which forms a coating of bituminous coal, the interior being a solid cylinder of sand and clay, without traces of organic structure, as is usually the case with Sigillaria, and like the upright trees in the coal-measures cut through by the Bolton Railway. The trees, or rather the remains

of stems of trees broken off at different heights above the root, vary in height from six to twenty-five feet, and in diameter from fourteen inches to four feet. There are no appearances of roots, but some of the trees enlarge at the bottom. They rest upon, and appear to have grown in, the mass which now constitutes the coal-seams and underlying shale, never intersecting a superior layer of coal, and never terminating downwards out of the coal or shale from which the stem rises. The underclay or shale often contains Stigmariæ. Here then, he states, are the remains of more than ten forests, which grew the one over the other, but at distant intervals, during which each, from the lowest upwards, was successively covered by layers of great thickness of clays and solid stone, the materials of which must have been arranged and consolidated under the surface of water, and the vegetation of every layer in which the upright trees are fixed must have grown on land.

The formation of coal-measures like the above, and of all others where there is evidence that the vegetable matter was not drifted to the place it now occupies, but must have grown on the spot, is then accounted for by supposing, that the land sank below the level of adjoining water; that gravel, sand and mud were washed down from the land that did not sink, and formed layers of clay and sandstone over the submerged forest, either in sufficient quantity to rise to the surface of the water and form land for the next forest, which was submerged in its turn, or that a contrary internal movement took place, which again raised the submerged land; and that for every seam of coal, one above the other, a similar series of changes must have taken place. It is to this oscillatory movement that Mr. Lyell ascribes the formation of the above remarkable phænomena in the Bay of Fundy, and others of a like nature.

At first sight, both theories seem well-founded, when applied to the particular coal-fields described; and it is possible that these eminent and experienced geologists may be of opinion that both are true, as applied to different situations. But I see great difficulties to the full acceptance of either, in many of the phænomena which, on a close examination, we find coal-fields generally present. As examples, I will call your attention to two sections that have very recently been published; the one a section of the western part of the South Welsh Coal-field, included in the valuable series lately issued from the Office of the Geological Survey of Great Britain, the work of W. E. Logan, Esq., a Fellow of this Society, so well known to us as an excellent observer, and as intimately acquainted with coal-fields, and who was formerly attached to that Survey; the other is entitled a "Section of the Nova Scotia Coal-Measures, as developed at The Joggins, on the Bay of Fundy, in descending order, from the neighbourhood of West Rugged Reef to Minudie, reduced to vertical thickness." It is also the work of Mr. Logan, who is now employed by the Government of Canada to make a Geological Survey of that country, and is contained in his Report to the late Governor Sir Charles Metcalfe, and transmitted by the Governor to the Legislative Assembly. And here I may remark, in passing, that while

we, as geologists, have to thank that provincial Government for commencing so useful an undertaking, we have also the satisfaction of feeling convinced that it will be prosecuted with vigour by the present Governor, Earl Cathcart, one of our own body, and, as we know, an able and active geologist. This is a section of the same series of coal-measures so carefully examined and described by Mr. Lyell*, though with less minuteness of detail as to the lithological characters and dimensions of the several beds. The phænomena exhibited in the above sections are not peculiar to them; they are to a great extent common to all coal-fields, particularly in the higher parts of the carboniferous series.

Before giving the analyses I have made of these sections, I wish to call to your recollection that in both theories it is assumed, that the deposition of the coal-measures took place *in the sea*. Mr. Lyell speaks of the accumulations having taken place in a sea: he says, "It by no means follows that a sea four or five miles deep was filled up with sand and sediment; on the contrary, repeated subsidences may have enabled this enormous accumulation of strata to have taken place in a sea of moderate depth."

The example from South Wales is a vertical section†, representing the beds as they are known to succeed each other in descending order, the dimensions being the thickness of each bed at right angles to the plane of stratification. The coal-measures rest upon carboniferous limestone, in an inclined and somewhat waved stratification; and although these measurements would vary in different places, from the swellings and thinnings-out which all strata exhibit more or less when traced to a distance, they are probably not far from the average amount over a large area.

1. From the top of the highest bed to the limestone, the sum of the measurements amounts to nearly 7000 feet; that is, the beds must have been originally deposited over each other in horizontal or nearly horizontal stratification to that thickness.

2. Reckoning only the greater divisions, when a difference of mineral character takes place, there are, besides the coal-seams, 340 beds, from a few inches to 190 feet thick, without alteration of mineral composition; involving, in the latter cases, long periods without any change in the nature of the detritus washed into the water where the deposition was going on.

3. These beds consist of sandstones, arenaceous and argilliferous slates, and clays, alternating without any apparent order of succession; sometimes one sometimes another lying upon the coal; and occasionally, but not frequently, the shale upon the coal is said to be carbonaceous.

4. Interstratified with these beds are *eighty-four* seams of coal, from one inch to nine feet thick; the highest being covered by a series of beds of sandstone, &c. 200 feet thick; the lowest seam separated from the carboniferous limestone by 1340 feet of similar sandstones and shales, making the *coal-bearing* strata 5460 feet in thickness.

5. The seams of coal occur at very unequal distances; some are separated by a few inches only of shale or sandstone, others by as much as 360 feet.

* 'Travels in America,' vol. ii. p. 178.

† No. 1 in the series, illustrating the horizontal section No. 7.

6. There are twenty-three seams, occurring in succession, most of which are not distinguished by any term indicating quality; in two instances, one a three-feet seam, they are said to be *bituminous*, and several seams are said to be *binding*, which means the same as *caking*, a quality which only richly-bituminous coals possess; the rest are merely called "Coal." These twenty-three seams with their interstratified sandstones and shales occupy 1840 feet.

7. Then succeed thirteen seams, in a space of 1000 feet, and nine of these are described as "*not bituminous.*"

8. The thirty-seventh seam, in descending order, is said to be *anthracitic*, and fourteen seams below it are so designated: then come four seams merely called "Coal," and all very thin. Beneath the lowest of these, and separated by sixty feet of arenaceous shales and sandstones, comes a bed of coal, four feet six inches thick, called *Anthracite*, with five feet of underclay; beneath this are seven seams called *Anthracite*, and three more are intercalated called *anthracitic*.

9. Between the thirty-seventh seam, called Anthracitic, and the lowest of all, which is called Anthracite, there are twenty-two seams intercalated, without having any distinctive term affixed to them, most of them very thin; but about midway, three occur near together, without intermediate sandstones and shales, but separated by clay containing Stigmariæ, in the following manner:—

	ft.	in.
Coal	1	0
Underclay	0	4
Coal	4	0
Underclay	8	0
Coal	1	4
Underclay	8	0

10. The seams of coal, whether termed merely "Coal," or bituminous, or anthracitic, or anthracite, have, with very few exceptions, underclays, and these, generally, but not uniformly, contain Stigmariæ. The two lowest beds of anthracite have underclays of five feet each, the third from the bottom has seven feet of underclay, each with Stigmariæ. The underclay is of variable thickness; in no part more than fourteen feet, and except in a few instances, is always said to contain the *Stigmaria ficoides*.

11. There appears to be no relation between the thickness of the underclay with Stigmariæ, and that of the coal resting upon it. The thickest seam of coal, which is nine feet, rests on three feet of underclay, and there are instances of a seam of coal only an inch thick, with five feet of underclay stated to be *filled with Stigmariæ*.

12. A bed of clay, eight feet thick, with Stigmariæ, has no coal upon it, but a foot of carbonaceous shale; and above that forty feet of arenaceous shale, then four feet of clay with Stigmariæ, covered by three inches of coal, and that overlaid by twenty-five feet of argillaceous shale and sandstone.

13. In no case is any difference stated in the mineral character of the sandstones or shales either *over or under* the Anthracite seams, or of any other coal-seam.

The example from Nova Scotia is a vertical section on the same plan as that in South Wales; and the coal-measures there also rest upon limestone, containing organic remains, "among which there is, in some abundance, a bivalve shell which Mr. Logan recognised as identical with *Producta Lyelli* of Windsor in Nova Scotia." This

limestone at Windsor Mr. Lyell describes as "a lower carboniferous limestone." The total vertical thickness of the coal-measures is more than double that of the South Wales section, being 14,570 feet.

a. The number of distinct beds in the section, of which separate measurements are given, is 1114, from six inches to 138 feet thick, without change in mineral composition.

b. These beds consist of quartzose sandstones, grits and conglomerates, and of arenaceous and argillaceous shales, all of various shades of red, grey, and green, without any apparent order of succession, sometimes one sometimes another lying upon the coal, and occasionally a carbonaceous shale is associated and intermixed with the coal-seams.

c. Interstratified with these beds are *seventy-six* seams of coal, from an inch to two feet thick, the far greater proportion very thin. The aggregate thickness of the seventy-six seams is only forty-four feet, and there is about the same aggregate thickness of carbonaceous shale. The highest seam is covered by a series of beds of sandstones, conglomerates and shales, 2274 feet thick. Beneath the lowest seam of coal there are 2800 feet of sandstones and shales of the same nature as those above, but having numerous beds of grey concretionary limestone intercalated. Thus the *coal-bearing* strata have a thickness of about 9500 feet.

d. There are no terms attached to the word "Coal" indicating any change of quality throughout the section. Some of the seams are called "Coaly clay," others "Carbonaceous shale" mixed with the coal. The seams occur at very unequal distances; from a few inches apart to more than 1200 feet.

e. As in the South Wales section, the coal-seams usually rest on beds containing *Stigmariæ*, but, in a great proportion of instances, these occur not in clay but in sandstone and arenaceous shale. This under bed is from a foot to twenty-seven feet in thickness; in one place an understone with *Stigmariæ* ten feet thick has a seam of coal over it only an inch thick.

f. Between the sixty-seventh and sixty-eighth coal-seams, the former with associated carbonaceous shale only fourteen inches thick, there are 170 beds of sandstone and argillaceous shale, from six inches to 132 feet thick, their aggregate thickness being 2620 feet, and the sixty-eighth coal-seam is only called coaly clay, two inches thick, with an underclay containing *Stigmaria* leaves of six feet.

g. In the 2274 feet of sandstones, &c. lying above the highest seam of coal, fragments of plants are seen in several of the beds; they first occur in a bed of sandstone 218 feet from the top, and the plants are converted into coal; they are often called "drift plants," and stated to be "coated with coal." In one bed there are "carbonized drift plants of large diameter," say one foot, the stems lying prostrate; and 1520 feet below this, there is a sandstone "fit for grindstones, with a few *Calamites* nearly at right angles to the plane of the beds, as if *in situ*, but forced over at the top;" this sandstone rests on a black carbonaceous shale two feet thick, but it is not stated whether the Calamites are fixed in this carbonaceous stratum. Between this last and the first seam of coal, which is only one inch thick, there are three feet of a "greenish-grey sandstone with *Stigmaria ficoides*," succeeded by two feet of "grey argillaceous shale with impressions of *ferns* and other plants."

Between the seventy-fifth seam, half an inch, and the seventy-sixth, two inches thick, are eighty-four beds of sandstone from a foot to 117 feet thick, together 1223 feet; and twenty of these beds, all called greenish-

grey sandstone, are said to contain carbonized drift plants; and in one of these beds there is said to be "a vast confused collection of carbonized drift plants; one lying prostrate measured twenty-five feet in length, and about one foot in diameter at the small end." So likewise in the 2800 feet of sandstones, &c. which are beneath the seventy-sixth or lowest seam of coal, ten of the beds are said to contain carbonized drift plants.

h. At a distance of 4400 feet from the surface there occurs a "bituminous limestone with shells and fish-scales," four feet thick, and lower down, in the succeeding 2000 feet, there are eighteen beds of similar bituminous limestone, one of them only half an inch thick, eleven of them under six inches, and the thickest two feet. Neither the shells nor the nature of the fish-scales are described, but that these are freshwater limestones may be inferred from this, that several of them are mixed with Stigmariæ and other plants: thus, associated with the twenty-eighth seam of coal is a "bituminous limestone and carbonaceous shale in alternate layers of one to three inches, with *plants*, shells and fish-scales;" under the thirty-first, "with Stigmariæ, shells and fish-scales;" along with the thirty-sixth, "black bituminous limestone with branches and leaves of *Stigmariæ* well-marked, and very minute shells;" under the forty-fourth, "with *Stigmariæ* branches and leaves, fragments of other plants, and minute shells." Mr. Lyell states that he observed "not far above the uppermost coal-seams with vertical trees, two strata, *perhaps of freshwater or estuary origin*, composed of black calcareo-bituminous shale, chiefly made up of compressed shells, of two species of *Modiola*, and two kinds of *Cypris*." It is possible, therefore, that the "minute shells" of Mr. Logan are *Cypris*. Beneath the lowest seam of coal are intercalated fourteen beds of what is called a "Concretionary limestone," and "Limestone in concretionary nodules," from one to three feet thick, one of them as much as eight feet, and in one instance the limestone is said to contain carbonized drift plants.

i. Several instances are given of stems of plants standing perpendicular to the plane of stratification; the first is 2160 feet from the top of the uppermost bed.

α. Calamites "as if *in situ*."

β. Lower down, 570 feet below *a*, two upright stems of Calamites, two inches in diameter, coated with coal, start from the top of a dark grey argillaceous shale, and penetrate into a grey shale with sandstone above. The length of the stems is not given.

γ. Forty feet below is a foot of sandstone and then a foot of shale, and "in this shale, and running into the sandstone above, is a Calamite at an angle of 45°: it appears to start from a coal-seam below, an inch thick."

δ. Beneath this, 640 feet, a seam of coal three inches thick occurs, and from it "there springs up an erect *Sigillaria* eighteen inches in diameter, and it penetrates the shale and sandstone above it, five feet of the plant being visible." Underneath the coal is "a grey sandstone with *Stigmaria ficoides* (*underclay*)."

ε. The next instance given is 1038 feet lower down, where, from a grey argillaceous shale, rises an upright *Sigillaria*, one foot in diameter, penetrating to a height of two feet into argillaceous shale above. There are sixteen feet of sandstone and shale below this *Sigillaria*, and *without Stigmariæ.*

ζ. The next is 270 feet lower, where, from an argillaceous shale, "springs an upright *Sigillaria* of one foot in diameter; the lower part commences to spread." There are seven feet of argillaceous shales, with ironstone balls, beneath this *Sigillaria, without Stigmariæ.*

η. The next is 228 feet lower, where from a "gray, crumbly, argillaceous

shale, like underclay, but no *Stigmariæ* visible, spring several upright Calamites, three of them in the distance of two feet, and eight more, the whole eleven in the distance of twenty feet."

θ. The next, 137 feet lower, in sandstone, are upright Calamites, three in the space of a foot.

ι. From a carbonaceous shale, a foot thick, sixty-two feet lower, "spring up erect Calamites, penetrating an arenaceous shale above two feet; and there are seven in the space of eight feet."

κ. The next is 254 feet lower, where, from an argillaceous shale, springs an upright *Sigillaria*, four inches in diameter; five feet of it are seen in a sandstone above. Argillaceous and carbonaceous shale beneath, six feet thick, does *not* contain *Stigmariæ*.

λ. From a grey argillaceous shale, twenty-two feet lower down, springs an upright *Sigillaria*. Its roots spread out into the shale, which is ten feet thick, and does *not* contain *Stigmariæ*; but *over* it lies a grey, crumbly, argillo-arenaceous shale or sandstone *with Stigmariæ*, in which six feet of the stem are visible. From the root of the plant proceeds a *Stigmaria* branch, which at first sight had much the appearance of being a root of the Sigillaria, but close inspection showed that the two, although touching, were distinct.

μ. The next is 108 feet lower, where, from a grey argillaceous shale, "springs an upright *Sigillaria*, eighteen inches in diameter, penetrating an incumbent sandstone." Fourteen feet of argillaceous shale and sandstone beneath do *not* contain *Stigmariæ*.

ν. The next is 133 feet lower, where, from a thin seam of coal with carbonaceous shale beneath, "rises an upright *Sigillaria*; the roots spread on the top of the coal; the plant is a foot in diameter, and only one foot of the length is visible."

ξ. The next is 160 feet lower, where, from a red argillaceous shale, springs an upright *Sigillaria*. Two feet of the length is seen, but it is cut clean off at the top and at the bottom by the measures which pass both without disturbance. No *Stigmariæ* occur for many yards below.

ο. The next is 101 feet lower, where, from grey argillaceous shale, six feet thick, without *Stigmariæ*, starts an upright *Sigillaria*, four inches in diameter; it is planted two feet in the shale, and penetrates the sandstone above, being four feet in length altogether.

π. The next is 362 feet lower, where, from a red and dark grey variegated shale, twenty-eight feet thick, with small balls of ironstone *and Stigmariæ*, arise two upright *Sigillariæ*. The roots of these spread out just on the top of the bed, and two feet of the plant are visible. The roots of the other spread out likewise, but they sink deeper into the shale by two feet, and the plant penetrates farther into the superincumbent sandstone."

ρ. The next distinct instance is 490 feet lower, where, from a grey argillaceous shale, several upright *Calamites* from half an inch to four inches in diameter penetrate an incumbent grey arenaceous and argillaceous shale containing prostrate carbonized plants. The roots of a Calamite three inches in diameter, spread on the top of the shale underneath; and twenty-one more Calamites are visible along the bank in the space of twenty yards.

This is the last instance stated of stems of plants found in the strata perpendicular to the plane of stratification; the seventeen instances thus occurring in a vertical thickness of 4515 feet.

Throughout the whole 7000 feet in the South Wales section, and, if the limestones are, as is most probable, of freshwater origin, also

throughout the 14,570 feet in the Nova Scotia section, there appears to be no trace of any substance of a *marine* character; and from anything exhibited in the composition of the beds, all might have been deposited in fresh water. It seems infinitely improbable, had the deposition taken place in a sea, that a series of accumulations of this description, implying, be it observed, a vast duration of time, with different depths and different qualities of sea-bottoms, should have taken place without a trace being discoverable, either upon the surface of the submerged layers of vegetable matter, or in any part of the clays and sandstones that lie upon them, of a marine animal or plant. It seems no less improbable, that, in a sea skirting a shore, there should be such an absence of agitation throughout so vast a space of time, as to allow a tranquil deposit of layers of fine detritus over a wide area, a spreading out of the leaves of delicate plants in layers of clay and sand like the specimens in a herbarium, and a gradual and insensible passage, in many instances, from one bed into another. Great as the North American lakes are, I am not prepared to say that grave objections may not be urged against the probable existence of such vast bodies of fresh water as would be of sufficient extent and depth to receive the beds of many coal-fields; but the absence of marine remains throughout vast depths of strata in coal-fields is a remarkable fact well deserving of the most careful investigation.

That the terrestrial vegetable matter from which coal has been formed has in very many instances been deposited in the sea is unquestionable, from their alternations with limestones containing marine remains. Such deposits and alternations in an estuary at the mouth of a great river are conceivable, but whether such enormous beds of limestone, with the corals and mollusks which they contain, could be formed in an estuary may admit of doubt. But it is not so easy to conceive the very distinct separation of the coal and the stony matter, if formed of drifted materials brought into the bay by a river. It has been said that the vegetable matter is brought down at intervals, in freshets, in masses matted together, like the rafts in the Mississippi. But there could not be masses of matted vegetable matter of uniform thickness 14,000 square miles in extent, like the Brownsville bed on the Ohio (the Pittsburg seam mentioned in page 170); and freshets bring down gravel, and sand, and mud, as well as plants and trees. They must occur several times a-year in every river; but many years must have elapsed during the gradual deposit of the sandstones and shales that separate the seams of coal. Humboldt tells us (Kosmos, p. 295) that in the forest lands of the temperate zone, the carbon contained in the trees on a given surface would not on an average of a hundred years form a layer over that surface more than seven lines in thickness. If this be a well-ascertained fact, what an enormous accumulation of vegetable matter must be required to form a coal-seam of even moderate dimensions! It is extremely improbable that the vegetable matter brought down by rivers could fall to the bottom of the sea in clear unmixed layers; it would form a confused mass with stones, sand and mud. Again,

how difficult to conceive, how extremely improbable in such circumstances, is the preservation of delicate plants, spread out with the most perfect arrangement of their parts, uninjured by the rude action of rapid streams and currents carrying gravel and sand, and branches and trunks of trees.

In the theory which accounts for the formation of beds of coal by supposing that they are the remains of trees and other plants that grew on the spot where the coal now exists, that the land was submerged to admit of the covering of sandstones or shale being deposited, and again elevated so that the sandstone or shale might become the subsoil of a new growth, to be again submerged, and this process repeated as often as there are seams of coal in the series —these are demands on our assent of a most startling kind. In the sections above examined, we have eighty-four seams of coal in the one, and seventy-six in the other. In the Saarbrück coal-field there are 120 seams, without taking into account the thinner seams, those less than a foot thick*. The materials of each of these seams, however thin (and there are some not an inch thick, lying upon and covered by great depths of sandstones and shales), must, according to this theory, have grown on land, and the covering of each must have been deposited under water. There must thus have been an equal number of successive upward and downward movements, and these so gentle, such soft heavings, as not to break the continuity or disturb the parallelism of horizontal lines spread over hundreds of square miles; and the movements must, moreover, have been so nicely adjusted, that they should always be downward when a layer of vegetable matter was to be covered up; and in the upward movements, the motion must always have ceased so soon as the last layers of sand or shale had reached the surface, to be immediately covered by the fresh vegetable growth; for otherwise we should have found evidence, in the series of successive deposits, of some being furrowed, broken up, or covered with pebbles or other detrital matter of land, long exposed to the waves breaking on a shore, and to meteoric agencies. These conditions, which seem to be inseparable from the theory in question, it would be difficult to find anything analogous to in any other case of changes in the relative level of sea and land with which we are acquainted.

That some seams of coal were formed of vegetable matter that grew on the spot where the coal now exists, seems to be proved in several cases (such, for instance, as that of the Bolton railway section) beyond dispute; and that some seams afford proofs of having been formed by drifted vegetable matter may be true. The coal-seams and the beds associated with them could be formed in no other way than under water; and the accumulation of the vegetable matter near the surface of it, and a very gradual submergence of the land, arrested at unequal intervals, appear to be the conditions most reconcileable with the phænomena. This implies, however, a deposition of the alternating sandstones and shales in very shallow

* Humboldt's Kosmos, p. 295.

water; and as we often find these rocks in regular thin stratification, forming the immediate bottom of coal-seams, the question arises, could such a laminated arrangement of detrital matter take place in water so shallow as is here supposed?

It is held by some geologists, that *Stigmariæ* are the roots of *Sigillariæ*, and that the stems of the latter contributed largely to the formation of coal. We should therefore expect to find, that where there is the greatest accumulation of *Stigmariæ* there should be the thickest seams of coal: this is not only not the case in the above sections, but sometimes there is no coal at all (11, 12, *e*, *f*, *g*). In a bed of sandstone 190 feet thick, in the South Wales section, and at a depth within it of sixty feet, there is a seam of coal four inches thick, without underclay and without *Stigmariæ*. Then again, in the Nova Scotia section, we find stems of *Sigillaria*, standing at right angles to the plane of stratification, resting on shales that do not contain any *Stigmariæ* (i, ζ, κ, λ, μ). Is this a proof that the stems are here, though apparently, really not in the place where they grew; or is it a proof that *Stigmariæ* are not the roots of *Sigillariæ*?

Several of the instances of upright stems given in the Nova Scotia section by Mr. Logan, can hardly be considered as occupying the spot were they grew, certainly not that (ξ) where it is cut clean off at the bottom. It is remarkable, that in the instances of upright stems described by Mr. Lyell and Mr. Logan, if occupying the spot where they grew, roots should so seldom be connected with them. Of all parts of the tree, none, we should expect, would be more likely to be preserved; being protected by their covering of soil from causes of destruction to which the stems were evidently exposed, as we find them so generally cut off at a short distance above their bases.

The whole subject of the theory of coal, whether we consider its mode of deposition, the plants out of which it has been formed, or the various changes which the vegetable matter has undergone to convert it into lignite, jet, common coal, cannel coal, blind coal and anthracite, two or more of these varieties often occurring in the same coal-field, is extremely obscure, and presents a wide and interesting field for future investigation. Before concluding this part of my subject, into which I shall probably be thought to have entered at disproportionate length, I would call your attention to some difficulties which the South Welch section offers to the commonly-received and, I believe, well-founded opinion, that anthracite is bituminous coal, the volatile parts of which have been driven off by heat acting gradually from below; for we see (8 and 9) that thin seams of common coal are interstratified with anthracitic seams and with anthracite. Neither do we find any signs of metamorphic action in the underclay in immediate contact with the coal, nor in the strata that lie between two seams of anthracite. We must look to the chemist to explain all this, as well as for enlightenment on the formation of the different qualities of coal; but we must be contented to receive from him only indications and resemblances; for we must never

forget, that in our experiments we can never have the volume of materials, the amount of pressure, and above all, the duration of time with which nature has worked; and each of these, singly and combined, must have had important influence in modifying the results.

Permian System.

The soundness of the principles on which Sir R. Murchison and M. de Verneuil first proposed to establish this great division, has been confirmed by subsequent observations both by themselves and by others, and appears to be recognised by the geologists of all countries. The name of Permian, too, has been as willingly adopted as that of Silurian was, being at once convenient and appropriate, and recalling the locality where a true type of the series can be referred to. In their first journey to Russia, only a part of the region where these rocks predominate was examined; but they saw enough then to satisfy them that some new classification was called for, and Sir R. Murchison developed his views and those of his associates at the Meeting of the British Association at Glasgow in 1840, and in a paper read before this Society in the following spring. In his Address as President at our Anniversary in 1842, he referred to his second journey in the summer of 1841, and announced the discovery, that these newer red sand deposits, covering an enormous portion of European Russia, constitute a separate zoological system, distinct in age from the Trias, and comprehending in ascending order our Lower New Red Sandstone (the *rothe-todte-liegende* of Germany), our Magnesian Limestone (the Zechstein of Germany), and the sandstones and conglomerates that constitute the lower member of the *bunter*, or variegated sandstone of the Germans (represented by the Grès des Vosges of France); and leaving the Trias, composed of the Upper Bunter-sandstein, Muschelkalk and Keuper, as the lowest of the secondary rocks, and the commencement of new orders in various forms of life. Sir R. Murchison maintained the same views in his Address of 1843; and in the spring of 1844, in a paper which he read to this Society, he gave a full confirmation of the correctness of his original conclusions, after a more careful examination of the fossils collected from the Permian series in Russia, and comparison of them with those collected in different parts of Germany and Poland, which countries he visited for the special purpose of examining *in situ* the characters of the lower members of the New Red Sandstone series in their long-established typical forms. The Permian system therefore consists of a series of conglomerates, sandstones, clays, marls, common limestones and magnesian limestones, all under a great variety of forms, and intermediate between the Carboniferous and Triassic groups. It contains a peculiar fauna and flora, mingled however with a proportion of the animal and vegetable remains of the Carboniferous series, on which its beds repose, and thus connected with the palæozoic class of deposits; whereas the Triassic series, which succeeds in ascending order, has not yet been found, it is said, to contain any palæozoic forms, whether animal or vegetable. The Permian system, the authors of the 'Geology of Russia' observe,

constitutes the remnant of the earlier creation of animals, and exhibits the last of the partial and successive alterations which those creatures underwent before their final disappearance. The dwindling away and extinction of many of the types, produced and multiplied in such profusion during the anterior epochs, and the creation of a new class of large animals, the Saurians, clearly announce the end of the long palæozoic period, and the beginning of a new order of zoological conditions.

It is remarkable however that palæozoic vegetable forms reappear, as I shall afterwards more particularly show, in beds much newer than the Trias; for in the Alps, in many parts of a series of beds which two such experienced geologists as M. Elie de Beaumont and M. Sismonda unhesitatingly declare to belong to the Liassic period, plants have been found which so skilful a fossil botanist as M. Adolphe Brongniart has not been able to distinguish from species found in the Carboniferous series. There is besides this peculiarity, that while the base of the Permian rocks frequently occurs in unconformable stratification with the Carboniferous, there is no example, it is said, in any part of Europe, of the Trias being found in stratification unconformable with the upper members of the Permian system. Too much stress however, Sir R. Murchison observes, ought not to be laid on this last circumstance, as evidence of a gradual passage in time from the Permian to the Triassic series, because sedimentary matter may be thrown down on the edges of older strata immediately after their dislocation, and that dislocation may have taken place without any great period having elapsed since the strata were deposited. On the other hand, if the sea-bottom were undisturbed, there might have been, so far as mineral structure is concerned, an immense interval of time between the deposition of two beds that are perfectly conformable, and even have a similarity in lithological character. And such in fact is the case. "Throughout whole regions of Russia the older deposits are clearly separable from each other by means of their respective fossils, although they are all apparently conformable."

The different memoirs which Sir R. Murchison had read before this Society made us acquainted with the leading features of the Permian system; but his great work on Russia has not only given us the evidence, at full length, of his opinions, but brings conviction to our minds by a more graphic and more impressive form of testimony than it was possible to produce in his abridged sketches. This system is developed on an enormous scale in European Russia, reposing upon carboniferous strata, throughout more than two-thirds of a basin which has a circumference of not less than 4000 English miles; that is, it occupies a space greater than twice the area of France.

The palæozoic series in North America ends with the carboniferous rocks; for although that and the inferior groups are developed on so great a scale, a narrow zone of red sandstone on the Atlantic slope, celebrated for containing the footmarks of giant birds, which in the opinion of Professor Rogers belongs to the Trias, is almost the only sedimentary deposit between the Carboniferous and the Cretaceous rocks.

The Secondary Rocks.

The Trias, so largely developed in other parts of Europe, is unknown in European Russia.

It is remarkable that, except one member of the oolitic series, the whole of the secondary formations between the Permian and Cretaceous groups should be wanting in Russia, and that with the exception of a very limited and even doubtful oolitic deposit in Virginia, not a trace of them should have been found from the Atlantic to the Mississippi, and even as far west from that river as any geologist has yet penetrated. Professor Rogers rests his determination of this deposit in Virginia as belonging to the lower part of the oolitic series, solely on the striking resemblance *as a group* of certain plants, accompanying a bed of coal which it contains, to those which are found associated with the oolite coal of Brora, Whitby, and other European localities. He says that, "judging by lithological indications alone, perhaps no more probable conclusion would have been reached on the subject than that of the able geologists Mr. Maclure and Mr. R. C. Taylor, the former of whom assigned this deposit, consisting of slates and of coarse grits composed of the materials of granite so little worn as to have the aspect of that rock in a decomposing state, and resting upon gneiss, and without any calcareous bed, to the period of the Old Red Sandstone; the latter to the "transition carboniferous deposits." If it be true, that in the Alps species of plants identical with those of the Carboniferous period have been found in undoubted Jurassic beds, it becomes doubtful whether the mere "resemblance as a group" of the plants in the Virginian beds is conclusive evidence, opposed as it is by the lithological character of the deposit, and the most remarkable circumstance of the entire absence of the oolitic series in any other part of the American continent. In a letter I had from Mr. Lyell, who last December passed through Virginia, he informs me that he had seen some specimens of coal plants and of ichthyolites from this deposit, which throw some doubt on its being of the oolitic age, especially when he compares the list with those from Connecticut, and that he intends to return to the spot in April next, in the hope of being able to determine their true age more precisely.

The only member of the oolitic series found in Russia is a representative of our Oxford clay and the beds immediately associated with it,—that which the French geologists call the *Terrain Oxfordien*. Nor, where these Jurassic beds occur, do they occupy any great extent of surface, but are in detached spots, at remote intervals, in isolated basins, patches or stripes. They are composed of slightly coherent dark-coloured pyritous shales, sands and calcareous concretions, sandstones and marlstones, very seldom solid calcareous beds, and throughout with a surprising uniformity of character. They are besides of little vertical thickness compared to the same series in other countries of Europe, the most considerable not exceeding 400 feet. They form low masses, which no doubt were at one time more connected, and have been subjected to powerful denuding causes.

They extend from the plains of Prussia to the frontiers of Asia on the east, and to the Frozen Ocean on the north. They are moreover seen to underlie the cretaceous and tertiary deposits of Southern Russia, and appear in the steppes which lead from Europe into Asia; but in these southern regions they undergo a change in lithological characters, becoming siliceous and calcareous grits, and resembling the conglomerates and grits found at the base of the oolitic series in some parts of England; their fossil contents however continue the same.

Cretaceous Rocks.

These occupy a great part of Southern Russia, but are unknown to the north of 55° of latitude. In regard to mineral arrangement, there exists that sort of general parallelism between the beds in Russia and those in Western Europe, particularly with those of Eastern Germany, which we might expect to find in strata of the same epoch separated from each other by great distances. Greensand, ironsand, chalk and chalk marl occur, in which the same groups of fossils prevail as in rocks of Britain and France which occupy the same relative age in geological succession; and pure white chalk, containing some characteristic organic remains, occurs at intervals to the confines of Asia. In the southern steppes of the Don Cossacks, on the banks of the river Donetz, chalk possessing all the characters of the English and French chalk, and containing some of its characteristic fossils, occurs of great thickness, Artesian wells having been sunk in it to a depth of 630 feet without any indications of a change of rock. It contains layers of flint, and the banks of the same river exhibit a section of a greensand group seventy feet thick, resting upon an equivalent of our coral rag, and surmounted by white chalk. A zone of true chalk, 120 miles in width, stretches through a great region about 100 miles south-west of Orenburg.

The cretaceous rocks occupy a very limited zone on the eastern side of the Alleghanies, extending about sixty miles, but having rarely a breadth of half a mile. They sweep round the southern extremity of these mountains, occupying a vast tract which stretches far westward of the Mississippi; and Mr. Lyell saw a collection of chalk fossils brought by M. Nicollet from the higher parts of the Missouri river. It appears further, from the recent report of Captain Fremont, that cretaceous rocks occur on the eastern flanks of the Rocky Mountains. The series examined by Mr. Lyell in the State of New Jersey consist of a lower portion of greensand and green marl, and above these a pale yellow limestone with corals, both however belonging, in the opinion of Mr. Lyell, who has carefully examined a large series of fossils, to the age of the white chalk, including the period from the gault to the Maestricht beds. As a detailed account of these beds and their fossil contents is given in the first volume of the Society's Journal, I need not dwell further upon them, except to give a statement of the general results. There is a remarkable generic accordance between the fossil mollusca,

corals, echinoderms, fish and saurians, and those of the same series in Europe; out of sixty shells collected by Mr. Lyell, five seem to be quite identical with European species, while several others approach very near to and may be the same as European; fifteen may be regarded as good geographical representatives of well-known cretaceous fossils, belonging for the most part to beds above the gault. This amount of correspondence is not small, when it is considered that the part of the United States where these cretaceous beds occur is from 3000 to 4000 miles distant from the chalk of Central and Northern Europe, and that there is a difference of 10° in the latitude of the places compared on the opposite sides of the Atlantic. "Some of the species common to the opposite sides of the Atlantic are those which in Europe have the greatest vertical range, and which might therefore be expected to recur in distant parts of the globe." He concludes with the following remarks:—"We learn from the facts mentioned that the marine fauna, whether vertebrate or invertebrate, testaceous or zoophytic, was divided at the remote period under consideration, as it is now, into distinct geographical provinces, although the geologist may everywhere recognise the cretaceous type, whether in Europe or America, and I might add India. This peculiar type exhibits the preponderating influence of a vast combination of circumstances prevailing at one period throughout the globe—circumstances dependent on the state of the physical geography, climate, and the organic world in the period immediately preceding, together with a variety of other conditions."

Tertiary Deposits.

The tertiary deposits of Russia, exclusive of a few patches of very recent age, are most expanded in the southern parts of the empire, those of Eocene and of Miocene ages both occurring. The former has in many parts the very same structure and contents as the London clay. Sections are seen of beds equivalent to the calcaire grossier and London clay in connexion with strata referred to the upper part of the cretaceous system. In the neighbourhood of Saratof, on the Lower Volga, there occurs a sandy calcareous grit, subordinate to clay and sand, of a concretionary structure, undistinguishable from the Bognor rocks in Sussex, and containing the same shells. The authors appear inclined to believe that an insensible gradation may be traced from the upper cretaceous into the tertiary beds.

The Miocene deposits are of far greater extent than the Eocene. They are the extension of the great basins of Vienna and Hungary, and are spread over Volhynia, Podolia and Bessarabia, stretching to the Black Sea and the country north of Odessa, where they are covered by deposits of a more modern age. They have a close affinity to the deposits of the sub-Apennines and of Bordeaux, and like beds of the same age in Styria and Hungary, contain extensive oolitic beds, undistinguishable, lithologically, from many English and French varieties of the Jurassic group.

Marine Pliocene deposits are wanting, but the Miocene are covered by the vast deposit of argillaceous limestone already referred to as

occupying the region around the Caspian, called by Sir R. Murchison the Aralo-Caspian or Steppe limestone, in which the univalves are of freshwater origin, associated with forms of Cardiaceæ and Mytili which are common to partially saline or brackish water. It abounds in many places with freshwater shells, and indeed presents the true and persistent characters of a deposit in an inland sea, and contains no vestiges of corals or other marine bodies. It was observed to be in some places between 200 and 300 feet thick, and at elevations of 700 feet above the present level of the Caspian. It possesses an uniformity of character which separates it from any tertiary deposit of Western Europe.

You are aware that Mr. Lyell read before this Society four papers on the tertiary deposits of the United States, which have been published in our 'Proceedings'; it is unnecessary therefore for me to give even a brief summary of them, and I shall content myself with stating some of the general results. On the Atlantic side of the Alleghanies, an area about 400 miles long from north to south, and varying in breadth from ten to seventy miles (with some detached patches further south), is occupied at intervals by tertiary deposits, which in the intermediate spaces are probably concealed by the more modern deposits and alluvium which form the surface. There are extensive tracts of Eocene formations, particularly in the south. Out of 125 species of shells which Mr. Lyell obtained from these deposits, he was not able to identify more than seven with species of the same epoch in Europe. But there are a considerable number of representative species, and an equal number of forms peculiar to the older tertiary strata of America. The *Ostrea sellæformis* may be considered as representing the *Ostrea flabellula* of the Paris and London basins, and appears to be one of the most characteristic and widely disseminated Eocene shells in this North American deposit.

The Miocene deposits are of far greater extent than the Eocene; and there is in them a close affinity of many of the most abundant species with mollusca now inhabiting the American coast, the proportion being about one-sixth of the whole, or about seventeen per cent., in those examined by Mr. Lyell, who was able to identify twenty-three out of 147 with living shells. The corals also agree generically with those of the Miocene beds of Europe, the cetacea also agree generically, and the fish in many cases specifically.

Metamorphic Rocks.

The theory of metamorphism in its more extended application, in recent times, to the explanation of the peculiar structure of certain stratified rocks, has thrown a clear light upon some of the most obscure and difficult parts of Geology. No geologist will now I presume hesitate to admit, that there is evidence amounting to demonstration that a permanent source of heat exists in the interior of the earth, widely spread beneath the stony envelopment, and that it has existed at all times. Whether it is local or widely spread under the surface—whether it is constantly maintained or is excited

at intervals by certain combinations, are questions for the solution of which we have as yet no data to lead us beyond probable inferences. It was long ago observed that when dykes of basalt passed through sedimentary rocks, earthy limestones were frequently changed into crystalline marble, shales into flinty slate, argillaceous sandstone into jasper, and bituminous coal into graphite or cinder. Similar changes were also often observed at the junctions of granite with sedimentary rocks. An attentive observation of these phænomena led Hutton to infer that the strata derived from the detritus of pre-existing rocks had been consolidated into stone by the agency of subterranean heat; and although he extended his theory to all the strata, to many which subsequent observations have shown it to be inapplicable, still the germ of the modern theory of metamorphism is clearly seen in one of the fundamental positions of the Huttonian theory of the earth. But sound as were the views of that philosopher in his leading doctrines, they were adopted by a very small number of geologists, so strongly had the theories and system of Werner got possession of men's minds, especially in Germany and France. About twenty years ago however some startling facts were brought to light; we heard that Belemnites had been found in micaceous schists in the Alps, and that an insensible passage could be traced from a secondary oolite full of organic remains, to the highly crystalline marble of Carrara, the old type of primary limestone, and under circumstances which afforded the strongest presumptive evidence that the oolite had been changed into the marble by the action of adjacent igneous rocks. Then there came facts on a grand scale analogous to those that had been observed at the junctions of trap dykes and granite veins with sedimentary rocks, and not only extending to great distances from the igneous rocks, but the secondary shales were changed into rocks that could not be distinguished from the so-called primitive gneiss and mica-schists, and like them included crystallized garnets.

Mr. Lyell, in 1833, brought forward a more extended and complete development of the Huttonian hypothesis of consolidation, and first proposed the adoption of the term "metamorphic" to this peculiar altered structure of sedimentary rocks,—a term which has been since universally adopted; and every year has disclosed new facts from all parts of the world, in confirmation of the theory that the older crystalline and indurated schists, limestones, dolomites and quartzites, and many similar beds of more modern date, were not deposited with a structure such as they now present, but were accumulations of detrital matter, *transformed* into their present condition mainly by the action of heat, accompanied by other chemical action, and the powerful agency of steam and elastic forces under enormous pressure. A very ingenious process, invented by Mr. Brockedon, described in a short paper read before us last year, by which he converts, under very powerful pressure, the powder of graphite into a solid mass having a conchoidal fracture, and undistinguishable from the most compact native black-lead, shows that pressure alone may convert fine detrital matter into solid stone.

It is not very long ago, far within our own time, since geologists spoke and wrote of chaotic fluids holding mineral matter in solution, and of precipitations of crystalline rocks from that menstruum. But these hypotheses, not only unsupported by, but at variance with all known chemical laws, are now laid aside, and we reason more soberly, interpreting past changes in the mineral structure of the earth by our experience of the laws by which the operations in the material world are governed. Every accession to our knowledge of the older sedimentary, highly consolidated, and semi-crystalline rocks, renders the probability greater that they were formed in the same manner as those now in progress of formation in existing seas; in short, that they originated from the waste of pre-existing lands. As Astronomy leads us to contemplations of immensity of distance in space, thus does Geology lead us to contemplate distances in past time almost as boundless; equally difficult for us to form a conception of, but, although not capable of measurement, not less certain. We are thus brought to admit the truth of another of the fundamental doctrines of the Huttonian theory, laid down by its author more than half a century ago, and some years afterwards so eloquently illustrated by his disciple and friend Playfair, whom I am proud to call my first master in Geology, "that in all the strata we discover proofs of the materials having existed as elements of bodies, which must have been destroyed before the formation of those of which these materials now actually make a part*." We learn from Professor Sedgwick, that in the north of England there are chloritic slates alternating with countless contemporaneous ribs of porphyry, as well as with trappean conglomerates and slaty beds, *derived mechanically from materials of igneous origin.* M. Abich of Dörpat considers that certain dark green grains disseminated through the lowest beds of the Lower Silurian "Pleta," or Orthoceratite limestone of Russia, are the detritus of the ancient augitic rocks of the Finnish frontier†. The least fragment of an organic body in the lowest deposits, it is evident, must have been encased in silt or mud, and that silt or mud must have been derived from pre-existing rocks, and most probably rocks exposed on land to the destructive power of meteoric agents. We are told by Mr. Lyell that the Potsdam sandstone, the lowest of the Silurian strata of North America, at the Falls of Montmorency near Quebec, is remarkable for containing *boulders* of enormous size—the largest he ever remembers to have seen, he says, in any ancient stratified rock. He measured some of them, which were eight feet long. They consist of the same gneiss as that on which the sandstone rests. He also observed in the same sandstone, on the borders of Lake Champlain, ripple-marks on the surface of its flags.

Several of the works of geologists which have been published during the last year have supplied much additional evidence of metamorphic action; none more important, I may say more conclusive, than is contained in the work of Sir R. Murchison on Russia,

* Illustrations of the Huttonian Theory, p. 5. † Murchison's Russia, i. 28.

and of Mr. Lyell on America, and in a very valuable memoir by M. Virlet. As far as my limits will allow, I will bring forward some of that evidence.

With limited exceptions, true granites are rarely found in the higher portions of the Urals, but they are of frequent occurrence in the lower regions, particularly on the Siberian side. The igneous rocks that enter into their composition are different forms of syenite, porphyry, greenstone, and felspar rocks, often graduating into each other, and associated with serpentine. These have evidently been erupted at different periods; and there are wide tracts occupied by granitoid rocks, which appear to have been erupted after the age of the carboniferous series, and posterior to the greater proportion of the greenstones and other eruptive rocks of the Urals.

It was only after Sir R. Murchison and his companions had become thoroughly acquainted with the slightly consolidated and unbroken sedimentary deposits in European Russia, that they were able to decipher the intricate characters of the indurated and crystalline strata which constitute the flanks, enter into the very body, and form lofty serrated ridges of the Ural chain; broken up and cast about in much apparent confusion. But from the presence of organic remains, traceable at intervals along both flanks, and even close to the axis of the chain, they were satisfied that some of the central ridges, although composed of chloritic, talcose, micaceous, and quartzose slates, cannot be of higher antiquity than the unconsolidated Lower Silurian rocks on the shores of the Baltic; and that others, although in a highly crystalline state, are not older than the Devonian and carboniferous series. The same rocks, when they recede from the great lines of eruption, resume their ordinary sedimentary characters. In one place the authors expressly say, that in proportion as they receded from the igneous zone, the sedimentary strata gradually parted with their talcose, chloritic and quartzite characters, and assumed the appearance of ordinary argillaceous schist, with bands of grit and sandstone, all parallel to the crystalline axis of the chain. In another place they describe certain Upper Silurian beds, consisting of alternations of argillaceous slate and black encrinite limestone, passing into talc-schist, and containing great flakes of mica. Between two great parallel lines of eruption they saw pure white saccharoid limestone containing Encrinites, and associated with other crystalline beds, which they were satisfied were once sandstones formed under the sea in the palæozoic period. In like manner the sedimentary rocks on the northern frontier of Russia, where they approach the great granitic and trappean region that stretches southward from Russian Lapland, become so changed, that the shales are converted into Lydian stone, the limestones into marbles, and the sandstones into indurated and sometimes granular quartz. These are not partial local effects, but characterize a long line of country in a broad zone. The authors observe, that "the thorough examination of this great band of Silurian rocks, more or less metamorphic, which lies between the purely crystalline or azoic rocks of the north and the wholly unaltered Devonian and carbo-

niferous deposits on the south, well merit the special attention of the geologist, mineralogist, and chemical philosopher; for the scale on which these operations of change have been conducted is gigantic. Our present acquaintance with the phænomena is however sufficient to convince us, that here, as in other countries, the consolidation, rupture, and alteration of large portions of the earth's crust have been effected by the agency and eruption of igneous and gaseous matter." A limestone—ascertained, both by lithological characters and fossiliferous proofs, to belong to the Devonian age, in which copper veins occur at a point where it is intersected in a complicated manner by greenstone porphyry—is converted, for a space 350 fathoms long and twenty wide, into a crystalline rock, in some places becoming a pure white crystalline saccharoid marble, and associated with it is a garnet rock, loaded with very beautiful and large crystals; a case somewhat analogous to that observed by Professor Henslow in Anglesea twenty-five years ago*, and to that in the neighbourhood of Christiania described by Mr. Lyell†. On the east flank of the Urals, south of Ekaterinburg, there is a succession of low ridges parallel to the main crest of the chain, composed of metamorphic rocks, some of them so micaceous that they might pass, the authors say, for primary mica-schist; others resembling gneiss, which a few years ago any geologist would have termed primary, but which are in fact only altered palæozoic sedimentary strata.

If we cross the Atlantic to North America, we obtain equally clear proofs of the alteration of the sand and mud of the lands of remote antiquity into crystalline schists, and of the forests that grew upon them into anthracitic coal, by this same powerful agency.

The Appalachian or Alleghany Mountains, which run from north-north-east to south-south-west for 1000 miles, varying in breadth from 50 to 150, and in height from 2000 to 6000 feet, have not, like the Ural chain, the features of a great rent in the earth's crust formed by elastic forces from beneath, and into which molten rocks were injected; they are composed of Silurian, Devonian and carboniferous rocks, in a series of nearly equal and parallel ridges formed by flexures of these rocks. The bending and fracture of the beds is greatest on the north-eastern or Atlantic side of the chain, and the strata become less and less disturbed as they extend westward, until at length they regain their original or horizontal position; thus offering between the Alleghanies and the western boundary of the basin of the Mississippi a country very similar in conformation to that between the Urals and the Baltic, and composed to a great extent of similar rocks. The internal movements which caused these flexures took place, as in Russia, subsequent to the carboniferous period; and on the eastern side the igneous rocks have invaded the strata, forming dykes, some of which run for miles parallel to the main direction of the mountains. These igneous rocks are largely developed to the north-east in the States of New Hampshire, Vermont and Maine.

Near Worcester in Massachusetts, Mr. Lyell observed mica-schist

* Cambr. Phil. Trans. vol. i. † Elem. of Geol. ii. 403.

containing beds of anthracite, the mica-schist including garnets and asbestus; and he states that he is strongly inclined to believe, that however crystalline they may be, they are no other than carboniferous rocks in a metamorphic state. There are many other places in Rhode Island and Massachusetts of similar transformations, especially in the neighbourhood of masses of granite and syenite*. The coal which, westward of the Alleghanies, is highly bituminous, as it approaches the igneous rocks to the east gradually loses its bitumen and gaseous contents, and is finally converted into anthracite.

The concluding part of the first volume of the second series of the 'Bulletin de la Société Géologique de France,' published last year, contains an interesting, and, in many respects, highly instructive account of the proceedings of the Society at their meeting at Chambery in August 1844. During the sixteen days it continued several valuable papers were read, and interesting discussions thereon are reported. Among others, the subject of metamorphism was frequently brought forward, and it appears to be the settled opinion of the most eminent French, Swiss and Italian geologists, who have thoroughly examined the Alpine regions, that a great proportion of the mica-schists, talc-schists and clay slates of the Alps, long held as types of primitive rocks, are unquestionably deposits of secondary age metamorphosed by igneous action. The neighbourhood of the place of meeting is described by the Archbishop of Chambery,—who took an active part in the proceedings, and who, from the communications he read, seems to be a zealous geologist,—as one of the countries of Europe the most interesting in this respect, and one in which the modifications of metamorphic action may be traced from its commencement to its extreme intensity with the greatest facility. At the conclusion of the meeting, M. Virlet read a paper on the participation which veins have had in metamorphic action, and brought forward some new views on the theory of metamorphism. He states that it has generally been held to be the result only of the action of plutonic rocks on the sedimentary deposits with which they come in contact, but that it is a far more complex operation, and is probably the result of several causes acting either simultaneously, separately or successively; among these he is disposed to ascribe much to the addition of new materials, insinuating themselves in the shape of gaseous emanations from the interior of the earth. He also dwells much on the matter injected into fissures, forming veins, as having had great effect, maintaining that in all metalliferous regions, the greater the number of veins by which they are traversed, so is the degree of metamorphism increased. He insists much on the metamorphic action of quartz veins, which he holds to be of eruptive nature, refers to the growing conviction among geologists, that in many cases there have been eruptions of veins of calcareous spar, and even ascribes the veins and slender ramifications of gypsum in the argillaceous beds of the lias of Burgundy and the other eastern provinces of France to eruptions of sulphate of lime.

* Lyell's America, i. 248.

Metallic Products.

The protrusions of igneous rocks along the line of the Urals were accompanied throughout a great part of the chain by the formation of numerous and extensive metallic veins, particularly on the eastern flanks, the chief seat of the metallic riches of Russia, especially in copper and iron. The geological details connected with these metalliferous rocks constitute a large and interesting part of Sir R. Murchison's work. One of the most important geological features connected with them, and it is one which appears to be well established, is the comparatively recent date of the eruptions which brought these metallic products of nature's crucibles within the reach of man. The accounts of the rich gold deposits are curious, and the ejection of the rock in which that metal is contained appears to have been very modern—little, if at all, anterior to the destruction of the mammoths, whose remains are entombed in the gravel which is found everywhere in the depressions of the Ural chain, and which covers vast regions of Siberia. The matrix appears to be quartz in the form of veins, but to find the gold in that state is extremely rare. It is found in lumps and grains that have been rolled, mixed with other detrital matter. A lump weighing about seventy-eight pounds English, found in 1843, is now in the Museum of the Imperial School of Mines at St. Petersburg.

Several curious facts are adduced to show that some of the ores of copper, particularly the green carbonate or malachite, are aqueous productions, derived from pre-existing ores, as calcareous stalagmites are derived from limestone rocks. In the copper mine of Nijny Tagilsk, at a depth of 280 feet from the surface, an immense irregularly-shaped botryoidal mass of solid pure malachite was found, of a bulk estimated at upwards of half a million of pounds weight, presenting in its interior the wavy radiations and silky structure of that beautiful mineral; almost identical in structure with many calcareous semi-crystalline minerals, of whose aqueous origin no doubt exists.

All the best iron of Russia is brought from the Ural chain and its flanks. It is found in veins in greenstones, and intermixed with the mass of erupted rocks of that class, often in great abundance at the junction of the igneous and stratified rocks, these last being in a metamorphic state. Magnetic iron ore is the chief form in which the metal is found, and it constitutes vast masses, sometimes worked in an open quarry.

Changes in the Relative Level of Sea and Land.

You are well aware that proofs of changes in the relative level of the sea and land along certain shores, particularly in the Baltic and Mediterranean, since our continents and adjacent islands were bounded by their present lines of coast, had attracted the attention of some of the earlier geologists; but it is only within a comparatively recent period that the discovery, in numerous instances, of the action of the sea at elevations far above its present level, in what have been termed *raised beaches*, has excited due attention

to this most important class of geological phænomena; changes which may almost be said to come within the range of our experience, and which appear to afford a key to the right solution of many analogous changes during periods long antecedent. We have for some time known that eroded rocks, and long lines of level beds or terraces of shingle, sand and clay, mixed with broken shells like what we now find at the sea-shore, are met with along the coasts of Sweden, and in Norway and the islands adjacent, from the Naze to the North Cape, and even to Spitzbergen. These beds of detritus, which have been found at elevations of 600 feet, and are sometimes above 160 feet in thickness, usually rest on the solid rock, and frequently contain shells in a perfect state of preservation as to freshness and colour, the bivalves, which are identical with species now living near the shore of the adjoining sea, retaining their uniting ligament; indicating that the changes have occurred, either during the latter part of the tertiary period, or at the commencement of the existing geological period. These facts are described in the writings of Playfair, Von Buch, Keilhau, Sefström, Lyell and others, and some very remarkable cases have recently been given in a memoir by M. Bravais*, who resided a year in Finmark, between the seventieth and seventy-first degrees of latitude, and who has measured with great care a series of terraces or raised beaches in the Alten Fiord, which extend over a line of coast from fifty to sixty miles.

The western coast of our own island has also, as you know, afforded some most remarkable instances of these changes of relative level of sea and land, from the north of Scotland to Cornwall, and in some cases at a much greater elevation than in Norway, as at Moel Tryfane in Caernarvonshire, more than 1000 feet above the sea. That they have not been found in as continuous extent in Britain as in Norway is perhaps owing to this, that the shores of our island being cultivated, these banks of loose materials would gradually become obliterated.

But it is not the shores of Europe alone that have afforded proofs of these changes; the continents of North and South America exhibit them on a far grander scale, both on the Atlantic and Pacific coasts. We are indebted to Mr. Darwin for descriptions of many remarkable instances; and some of these which have recently come again under our notice, in the second edition of his 'Journal,' published within the last few months, I will draw your attention to: I know no geologist whose observations, and the inferences he draws from them, are more to be relied upon; for he examined the country he describes evidently uninfluenced by any preconceived opinions. They have besides a bearing upon some fresh accessions to our knowledge of facts of this description, both in Europe and North America, during the past year.

At Coquimbo, in northern Chile, five narrow, gently sloping, fringe-like terraces rise one behind the other, and, where best developed, are formed of shingle. At Guasco, farther north, the terraces

* A translation of this valuable memoir is given in the fourth number of the Quarterly Journal of the Geological Society.

are much broader, and may be called plains, and they run up the valley for thirty-seven miles from the coast. Shells of many existing species not only lie on the surface of the terraces, to a height of 250 feet, but are imbedded in a friable calcareous rock, which is in some places as much as from twenty to thirty feet in thickness; and these modern beds rest on an ancient tertiary formation, containing shells apparently all extinct. "The explanation of the formation of these terraces must be sought for, no doubt, in the fact, that the whole southern part of the continent has been for a long time slowly rising, and therefore that all matter deposited along shore in shallow water must have been soon brought up and slowly exposed to the wearing action of the sea-beach*." He describes a great valley near Copiapo, reaching far inland, the bottom of which, consisting of shingle, is smooth and level; and states that he has little doubt that this valley was left, in the state in which it is now seen, by the waves of the sea, as the land slowly rose†. He then goes on to state, "I have convincing proofs that this part of the continent of South America has been elevated near the coast at least from 400 to 500, and in some parts from 1000 to 1300 feet, since the epoch of existing shells‡." Speaking of the neighbourhood of Valparaiso he says, "The proofs of the elevation of this whole line of coast are unequivocal: at the height of a few hundred feet old-looking shells are numerous, and I found some at 1300 feet. These shells either lie loose on the surface, or are imbedded in a reddish-black vegetable mould. I was much surprised to find, under the microscope, that this vegetable mould is really marine mud, full of minute particles of organic bodies §."

So far for instances of changes in the relative level of sea and land on the western shores of the continent; they are no less conspicuous on the Atlantic side. "The land from the Rio Plata to Tierra del Fuego, a distance of 1200 miles, has been raised in mass (and in Patagonia to a height of between 300 and 400 feet) within the period of now existing sea-shells. The old and weathered shells left on the surface of the upraised plain still partially retain their colours. The uprising movement has been interrupted by at least eight long periods of rest, during which the sea ate deeply back into the land, forming at successive levels the long lines of cliffs or escarpments which separate the different plains, as they rise like steps one behind the other ||."

Now it is important to observe, that in some of the above instances, and also in others which Mr. Darwin gives, the proofs of change are not in terraces or raised beaches only, but that there are broad expanses of land far from the coast, where marine shells of existing species lie near the surface and upon it; in other words, that we have that which recently was a sea-bottom now forming an elevated part of the continent.

The authors of the 'Geology of Russia' have described a sea-bottom, extending nearly 200 miles inland from the shores of the

* Journal of a Voyage round the World, 2nd edit. p. 344. † Ibid. 355.
‡ Ibid. 357. § Ibid. 254. || Ibid. 171.

Arctic Ocean, which they were the first to discover. In ascending the Dwina, which flows into a bay of the Icy Sea at Archangel, they discovered at about 150 miles from that city, near where the Vaga, a tributary, falls into the Dwina, a profusion of shells having a very modern aspect, regularly imbedded in clay and sand of about ten feet in thickness, which, covered by about twenty feet of the coarse gravel and detritus of the country, reposed on red and white gypsum, subordinate to red marls of the Permian system of rocks. They traced these shelly beds to a distance of about eight miles. Some of the shells preserved in the blue clay or marine sand, and thereby excluded from atmospheric influence, have retained all the freshness of their original colour, with their valves often united; and the whole, even when blanched, are generally in a good state of preservation. What they collected were carefully examined by skilful conchologists. Dr. Beck of Copenhagen considered all he examined to be identical with those now existing in northern seas which range from 42° to 84° north latitude. Mr. Smith of Jordan-hill was of opinion, that though many of these species are recent, some are of peculiar varieties, now found in desiccated and elevated sea-beaches only. Mr. Lyell recognised the group as identical with that which he had described from Uddevalla in Sweden, a distance of a thousand miles from the Dwina; and Mr. G. Sowerby stated, that the shells, though on the whole an association of existing species, have yet among them forms seldom, if ever, found except in raised sea-bottoms of a subfossil character. The authors estimate the place where these shelly beds occur to be about 150 feet above the sea at Archangel, and consider them to afford undoubted evidence that the land, from the Vaga to Archangel, was a sea-bottom during the period of existing species. A similar estuary appears to have existed about 300 miles eastward, in the valley of the Petchora; for Count Keyserling found fragments of sea-shells, apparently of existing arctic forms, at a distance of 180 miles from the present embouchure of that river, strewed upon argillaceous slopes in the depression of the valley. He further observed, that they do not occur in the adjoining plateaux; and that these higher grounds are occupied by sand, gravel and clay, containing here and there bones of the mammoth, from which he infers, that the shelly deposits were formed in a bay of the sea that extended far into low lands, which were then inhabited by great extinct mammalia.

In the sketch given by the same authors of the structure of Siberia, they adduce a body of very satisfactory evidence to justify the inference they draw, that the vast region in which the bones of Mammoth, Rhinoceros and *Bos Urus* are so abundantly dispersed, and especially the wide and low tract of northern Siberia, and all the low promontories between the Obe, the Yenessei and the Lena, were elevated at a period long subsequent to the time when large herds of these animals for many successive generations inhabited that region. Following up the views first propounded by Mr. Lyell, to whom they do full justice, they infer that the change of climate, the diminished temperature, occasioned by the increase

of land when the sea-bottoms of these estuaries and shores were upraised, caused the extinction of these great quadrupeds.

Although the great tract of country from the Baltic to the elevated region westward of the Ural Mountains has not been locally broken up by eruptive rocks, there is ample evidence to prove that it has been subjected to the action of subterranean forces, which elevated the whole region, after the deposition of Miocene tertiary beds, and after the land, while submarine, had assumed its present form. "From the German Ocean and Hamburgh on the west to the White Sea on the east, a vast zone of country, having a length of near 2000 miles, and a width varying from 400 to 800 miles, is more or less covered with loose detritus, including erratic crystalline blocks of colossal size, the whole of which blocks have been derived from the Scandinavian chain." The eastern and south-eastern boundary of these erratic blocks mark the line of coast westward of which all the land as far as the shores of the Baltic was then submerged. Between that line of coast and the Urals is the region that constitutes the Governments of Perm, Viatka and Orenburg; and for a considerable space to the west of the Ural there is not a vestige of any superficial deposit which can be referred to the influence of the sea. "We believe, therefore," say the authors, "that the region so characterized was really above the waters, and inhabited by mammoths, when the erratic blocks were transported over the adjacent north-western sea." The amount of this elevation, subsequent to the covering of the sea-bottom by the northern drift, must have been at least from 800 to 1000 feet; for the tops of the Valdai hills, a range on the eastern borders of Lithuania, and to the south of the Government of St. Petersburg, which rise in some places to that height, are covered with these blocks on their southern slopes.

Mr. Lyell, speaking of the country near Savannah in North America, says, "It is evident that at a comparatively recent period, since the Atlantic was inhabited by the existing species of marine testacea, there was an upheaval and laying dry of the bed of the ocean in this region. The flat country of marshes was bounded on its inland side by a steep bank or ancient cliff, cut in the sandy tertiary strata; and there are other inland cliffs of the same kind, at different heights, implying the successive elevation above the sea of the whole tertiary region." In a letter which I received from him a few days ago, dated from Savannah, Mr. Lyell tells me "that he had seen on the coast of Georgia quite a counterpart of the terraces, or successive cliffs of Patagonia, cut out of the tertiary deposits." But there are also evidences on that coast of a downward movement at the present time. Mr. Lyell says, "There have also been subsidences on the coast, and perhaps far inland; for in many places near the sea there are signs of a forest having become submerged, the remains of erect trees being seen enveloped in stratified sand and mud. I even suspect that this coast is now sinking down at a slow and insensible rate, for the sea is encroaching and gaining at many parts on the freshwater marshes. . . .Everywhere there are proofs of the coast having sunk, and the subsidence seems to have gone on in very modern

times." Speaking of some phænomena connected with a boulder formation at Brooklyn near New York, he says that he had come to the conclusion "that the drift was deposited during the successive submergence of a region which had previously been elevated and denuded, and which had already acquired its present leading geographical features and superficial configuration." In the region near the Falls of Niagara, on Lake Ontario, and in the valley of the St. Lawrence, he enumerates many unequivocal proofs of emergence and submergence during the modern period now under consideration. He states that in the valley of the St. Lawrence he seemed to have got back to Norway and Sweden, passing over enormous spaces covered by deposits so modern as to contain exclusively shells of recent species, resting on the oldest palæozoic and older non-fossiliferous rocks. Wide areas are covered with marine shells of *recent* species, at the height of 500 feet above the sea, and where all the rocks can be shown both to have sunk and to have been again uplifted bodily, for a height and depth of many hundred feet, since the deposition of these shells. At the village of Beauport, three miles below Quebec, he made a collection of shells from a cliff consisting of a series of beds of clay, sand, gravel and boulders; and he states that when they arrived in London, Dr. Beck of Copenhagen happened to be with him, and "great was our surprise," he adds, "on opening the box to find that nearly all the shells agreed specifically with fossils which, in the summer of the preceding year, I had obtained at Uddevalla in Sweden, and figured in my paper "On the Rise of Land," &c., in the 'Philosophical Transactions' for 1835. Among the species most abundant in these remote regions (Scandinavia and Canada) were *Saxicava rugosa*, *Mya truncata*, *M. arenaria*, *Tellina calcarea*, *T. Grœnlandica*, *Natica clausa*, and *Balanus Uddevallensis*. All of them are species now living in the northern seas; and whereas I had found them fossil in latitudes 58° and 60° N. in Sweden, Captain Bayfield sent them to me from a part of Canada situated in latitude 47° N."

Ascending the St. Lawrence, he found near Montreal, at a height of about sixty feet above the river, great numbers of the *Mytilus edulis*, retaining both valves and their purple colour, associated with *Tellina Grœnlandica* and *Saxicava rugosa*, in horizontal beds of loam and marly clay. He found the same shells at ninety feet associated with boulders of gneiss and syenite three feet in diameter, characteristic of the Canadian drift; and he was afterwards conducted to a hollow between the two eminences which form the Montreal mountain, where he found a bed of gravel six feet thick, containing numerous valves of *Saxicava rugosa* and *Tellina Grœnlandica*. This bed he estimates at 540 feet above the sea, 306 feet above Lake Ontario, and only twenty-five feet below the level of Lake Erie.

Such comparatively modern changes in the relative level of the land and sea, were ascribed by the earlier geologists, and are by some still ascribed, to a rising or sinking *of the sea*. Playfair, nearly half a century ago, combating this opinion maintained by the Swe-

dish naturalist Celsius, demonstrated the untenable nature of such a hypothesis; it was he who first showed that these changes of relative level are alone explicable by the movements *of the land*, and that a permanent change of level of the sea, in detached regions of the earth's surface, is physically impossible. "The imagination," he says, "naturally feels less difficulty in conceiving that an unstable fluid like the sea, which changes its level twice every day, has undergone a permanent depression in its surface, than that the land, the *terra firma* itself, has admitted of an equal elevation. In all this, however, we are guided much more by fancy than by reason; for, in order to depress or elevate the absolute level of the sea, by a given quantity, in any one place, we must depress or elevate it by the same quantity over the whole surface of the earth; whereas no such necessity exists with respect to the elevation or depression of the land. To make the sea subside thirty feet all around the coast of Great Britain, it is necessary to displace a body of water thirty feet deep over the whole surface of the ocean. It is evident that the simplest hypothesis for explaining those changes of level, is, that they proceed from the motion, upwards or downwards, of the land itself, and not from that of the sea. As no elevation or depression of the sea can take place but over the whole, its level cannot be affected by local causes, and is probably as little subject to variation as anything to be met with on the surface of the globe*".

Notwithstanding that this unanswerable doctrine was thus clearly laid down so far back as 1802, we still find geologists of authority speaking *of the sea* having risen or fallen, in their endeavours to explain certain phænomena. I have within the last year heard this said repeatedly in this room; and in a recent excellent paper of my friend Mr. Maclaren of Edinburgh, on Boulders and grooved and striated Rocks observed by him on the shores of the Gare Loch in Dumbartonshire, an excellent observer, and in general a sound reasoner, I find such expressions as the following:—"The anomalous presence of granite boulders at Gare Loch seems best explained by assuming that they were floated on icebergs from Ben Cruachan, Ben Nevis, or some other of the lofty granite mountains of the north .... *The sea must then have stood perhaps* 1500 *feet above its present level*, to permit the rafts of ice to pass over the lowest part of the barrier. ... An iceberg starting from the West or North Highlands, *and floating in a sea* 1500 *or* 2000 *feet above the present level of the Atlantic*, is an agent perfectly capable of effecting the transportation of the stone, and offers, I think, the only conceivable solution of the difficulty .... *When the sea stood, as it certainly once did stand*, 1000 *feet or more above its present level*, a current would set eastward through the gulf then occupying the low lands, of which the estuaries of the Forth and Clyde form the extremities." Speaking of an ancient beach thirty-two feet above the present high water line on the shore of Gare Loch, he says, "We may infer that when the glacier occupied the valley of Gare Loch, *the sea stood higher than it does now by at* least thirty feet, and probably a great

* Illustrations of the Huttonian Theory, p. 446.

deal more*". It is possible that these may be mere inaccuracies of expression in describing changes of relative level of sea and land, but if they are so they ought to be guarded against, for they may be very easily misapprehended ; and they tend to perpetuate an error that leads to the most false reasoning on many changes on the earth's surface.

If the land of Norway had been immovable, if the sea had fallen from a higher level, the lines of its former shores, as it sank at intervals, would have been continuous and parallel; but the raised beaches are, within short distances, at different elevations ; other observers had remarked this, but it is to M. Bravais that we are indebted for the first exact measurements of the relative positions of the successive terraces, and these have demonstrated that their parallelism is only apparent. During his residence on the Alten Fiord, near North Cape, he extended his levelings over a space of from nine to ten myriametres, that is, from about fifty-five to sixty-two English miles ; and he ascertained that the two great lines of ancient level there, which are on a slope rising from the sea, come nearer and nearer to each other as they approach the present shore; their greatest elevation is in the upper part of the Fiord, and they are there widest apart. It is evident therefore that the movement of the land has been different in different parts of the fiord. It seems as if the continental mass had been elevated with an inclination seaward, the axis of motion corresponding nearly to that of the great chain of the mountains of Norway. It is most desirable that measurements similar to those of M. Bravais should be made in all places where there are terraces or raised beaches one above another along our coasts. Mr. Darwin's explanation of the parallel roads of Glen Roy, that they are ancient sea-beaches, appears to be now generally accepted ; and it would be most interesting if it were ascertained by exact levelings, such as those of M. Bravais in the Alten Fiord, whether they are really parallel; because, as M. Bravais well remarks, they may seem so to the eye, which can take in only a small part of the space they occupy, while exact measurements might prove that the appearances are deceptive.

That land in various parts of the earth has undergone movements of elevation and depression, and that it has been subject to such oscillations at all times, up to the present day, admits I think of no doubt; without therefore going quite so far as my friend Mr. Darwin, who tells us that "daily it is forced home on the mind of the geologist, that nothing, not even the wind that blows, is so unstable as the level of the crust of this earth," still I believe it may be safely affirmed, that the stability of the sea and the mobility of the land must be acknowledged to be demonstrated truths in Geology.

Boulder Formations and Erratic Blocks.

The geologically modern changes in the relative level of sea and land are intimately connected with the history of the vast accumu-

* Edin. Phil. Journal, January 1846.

lations over Northern Europe and North America of detrital matter, in the form of sand, clay, gravel, boulders, and huge erratic blocks, and of the grooved, striated and polished surfaces of hard rocks which usually accompany them. This great problem, complicated in its nature and full of difficulties, has of late years more particularly arrested the attention of geologists; and it must long continue to do so before a sufficient mass of observations can be collected on which a satisfactory solution of it can be founded. Although, as regards Europe, many important local facts, exhibited in limited districts, have been well described by several geologists, both of this country and of the continent, we are indebted for the most extended observations and the most comprehensive views of the subject to the labours of Keilhau, Sefström, Durocher, Murchison, De Verneuil, and Forchhammer. The geologists of the United States, and Lyell, have brought together a great body of evidence respecting the same phænomena in North America. There is reason to infer, from the limited observations that have been made along the shores of Siberia, that the boulder formation extends also over Northern Asia.

Many new observations have been made known to us during the last year, by the authors of the 'Geology of Russia,' by Mr. Lyell in his 'Travels in the United States, Canada, and Nova Scotia,' and by M. Durocher in an additional memoir which he read last December before the Geological Society of France, describing observations made by him in Norway during the preceding summer.

You are aware that Agassiz and Charpentier have attempted to explain the phænomena by supposing, that at a very recent geological period, since the time when the land had assumed its present form, Northern Europe was covered with a vast mantle of ice, and that the detritus and erratic blocks have been formed and transported by the agency of sub-aërial glaciers, in the same manner as moraines have been accumulated, blocks transported, and rocks furrowed, striated, rounded and polished by the glaciers descending from the Alps. Abundant evidence has been brought forward to demonstrate, that by no such action can the phænomena be explained; and all the geologists mentioned above, who have carefully investigated them, reject the theory as inapplicable to Northern Europe and America, except in a very limited sense.

The Boulder Formation, or Northern Drift, and The Erratic Blocks, are shown, by the authors of the 'Geology of Russia,' to be two distinct classes of phænomena; the latter being usually angular, the materials of the former being rounded and worn by attrition. It appears to me to have been clearly proved that the boulder formation is not the work of a sudden transient action of short duration, but the result of operations that were going on during the middle tertiary deposits, and in Europe extended at least to the Pleistocene period; that the greater part of the accumulations took place since existing species of testacea inhabited the adjoining seas; and that the transport of erratic blocks took place at a later period. It seems to be no less clearly established, that the boulder and drift accumulations and the erratic blocks now covering the dry

land were deposited upon a sea-bottom which has been since upraised. Where the smaller detritus and rounded boulders came from, and how they were drifted into their present situations, are branches of the subject involved in great obscurity. That fragments of hard rock were the tools which graved the furrows and striæ, and polished the surfaces of hard rocks they passed over, is pretty evident; but what held and guided the tool, what force applied it, to what extent ice, and to what extent water was the agent, is not so clear; that both have acted there can be no doubt. It is, I think, very satisfactorily shown, that the erratic blocks must have been brought down from lofty mountains, to the open sea that washed their bases, by glaciers; that they were floated to great distances by masses of ice breaking off from these glaciers, to form icebergs, in different directions from central points, and stranded on elevated parts of the sea-bottom, without having been subject to much attrition; and, moreover, that these erratic blocks can, in a great number of instances, be traced to their parent rock, though now separated some hundred miles. Some of the evidence in support of these positions, supplied during the last year, I will now bring forward. I regret that my limits will not allow me to do greater justice to the authors to whom we are indebted for it, either as regards their facts, or their deductions from these facts.

The boulder formation and erratic blocks cover an enormous area, from the Arctic Sea over a great part of Northern Europe; not continuously, but often uninterruptedly over vast regions. The masses of clay, sand and gravel are sometimes of so great thickness that it is impossible to detect a trace of the subjacent solid rock, over very wide tracts, even in the beds of the Volga and the deepest cutting rivers. M. Durocher, in his first memoir *, did not trace the erratic blocks farther east than the forty-second degree of longitude, nor farther south than the fifty-fifth degree of north latitude; but the authors of the 'Geology of Russia' have described them as extending 500 miles farther east, and above 200 miles farther south. As the parent rocks of most of these huge fragments are in Scandinavia and Finland, they have been in some instances transported to a distance of 800 miles in a direct line †. It is possible that the *boulder formation* may extend somewhat farther, but probably not much; for there is reason to believe that land on the east and south was above the level of the sea, as has been already stated, at the time the country to the west and north was submerged, which would stop the advance of the boulder formation and erratic blocks, but in an irregular line. No erratic blocks of northern origin have been seen for a considerable distance westward of the Ural Mountains.

There is a feature in the character of this superficial covering of detritus which is very important to attend to in tracing its history, viz. that the materials are not always the same; that the principal mass in each district is of local origin, and very clearly bespeaks its derivation to be in the subjacent rocks; and that the great northern

* Comptes Rendus, Janvier 1842. † Map accompanying 'Geology of Russia.'

drift is distributed in the form of long sand-banks, "*trainées*," or "*osar*," as they are called in Sweden, often of great length and breadth, and rising sometimes more than 100 feet above the depressions between them, which last are occasionally of great width. These trainées are often composed of finely laminated sand and clay, containing shells identical in species with those now living in the Baltic or in the northern seas; they traverse, from the shores of the Baltic, the Silurian, Devonian, and carboniferous regions in succession, deriving new materials from each zone of rocks crossed, but always indicating a southerly direction of the drift, the Devonian detritus never being found in the Silurian zone, nor the carboniferous in the Devonian zone.

Mr. Forchhammer describes the boulder formation of Denmark as being of different ages. The oldest which affords any distinct evidence to mark its age consists of a congeries of clays, marls, and sands, which have been traced to a depth of several hundred feet, and contain boulders throughout the entire mass, extending to the deepest part of the series. The boulders, sometimes several hundred cubic feet in size, are of granite, gneiss, porphyry, greenstone, and quartz rock, and also of transition (Silurian) sedimentary rocks; none of these occurring nearer than Norway and Sweden. Besides these travelled blocks, there are many parts of the formation composed of chalk, identical with rocks upon or near to which the boulder formation occurs. In the duchy of Schleswig, this boulder formation *alternates* with beds of Brown Coal, a deposit which extends over the greater part of Denmark, and which, besides brown coal, consists of clays, limestones and sandstones, containing fossils that in the opinion of Mr. Forchhammer mark it to be identical with the sub-Apennine group. The causes which produced this boulder formation, in part at least, were therefore in operation as early as the Miocene tertiary period (if, as some maintain, the sub-Apennines are of that age), during which the sea, overspread at its bottom by this detritus, was inhabited by Mediterranean species. There is clear evidence in the works of the authors I have quoted, of the operation of the same causes long after the northern seas were inhabited by existing species; and throughout the whole of this period, how long we have no means of determining, all the land in Northern Europe overspread by the boulder formation must have been under the sea. Thus the authors of the 'Geology of Russia' describe the deposit of recent shells in the valley of the Dwina, 150 miles inland from Archangel, as covered by sand and gravel, which, they say, they would have great difficulty in separating from the superficial northern drift; and they add, that "a recent excursion through Sweden has convinced them that in the neighbourhood of Upsala, marine post-pliocene deposits, containing the *Tellina Baltica*, are there covered by coarse gravel and large erratic blocks, as stated by Mr. Lyell."

The ingenious and ardent naturalists of Switzerland, who have held that the boulder formations of Northern Europe were produced by sub-aërial glaciers, never could have advanced so extravagant a

theory had they visited that region and been even moderately acquainted with the facts above stated, and others which as indisputably prove a submarine origin. But there is every reason to conclude that glaciers in high lands in Scandinavia, Finland and Lapland, in very remote times, had much to do with the origin of *the erratic blocks*, in separating them from their parent rocks and transporting them to the coast. Sir R. Murchison informs us that he was assured by Dr. Wörth, a distinguished mineralogist of St. Petersburg, that after a careful examination of the numerous blocks scattered around that capital, there was not among them a single example which could not be paralleled with its parent rock in Finland. Speaking of the observations of himself and his companions, he states that near Jurievitz on the Volga, they found erratic blocks of a quartz rock associated with others of a trap breccia peculiar to the north-western side of Lake Onega, affording clear evidence that they had been transported in a south-eastern direction, 500 miles from their parent rocks.

If the blocks were encased in and transported by icebergs, they would be accumulated chiefly on the ridges and higher parts of the sea-bottom, by which the progress of the icebergs would be arrested, and where the icebergs would be fixed until they gradually melted, leaving their stony cargo on the spot. Such we find to be the fact. The great accumulations of the blocks are not in the valleys, but on the high grounds. The summits of the cliffs on the south shores of the Gulf of Finland, at an elevation of 150 feet above the sea, are covered with angular blocks of the granite, gneiss and porphyry of Finland; they are found on the hills adjoining Lake Onega, at elevations from 400 to 600 feet above the lake; the Valdai Hills, which are in some places 1000 feet above the level of the Baltic, have arrested large quantities of blocks from Finland, which are profusely spread over their southern slopes. In the sandy plains east of Posen, not a block is to be seen for several miles, until the elevations towards the Polish frontier are reached, and they again become numerous. In the sandy plain the blocks are usually small, but on the hills between Konin and Kolo, vast numbers of large blocks are buried in and mixed with sand at heights of 300 or 400 feet above the sea.

A very important circumstance in the history of these erratic blocks is pointed out by the authors of the 'Geology of Russia,' viz. that they have not travelled from north to south only, but in all directions from certain centres in Scandinavia and Lapland. In Denmark they have come from north by east; in most parts of Prussia almost direct from north; opposite the coasts of Finnish Lapland, where the granitic and other crystalline boundary sweeps round to the north-east, the direction of the blocks changes accordingly. Near Nijni Novgorod they must have travelled from north-west to south-east; and in the Government of Vologda they have nearly an eastern course. By the observations of Böhtlingk we learn that the erratic blocks of Scandinavia have been shed off from the coast of Kemi into the bay of Onega, and from Russian Lapland into the

Icy Sea, in north-eastern, northern, and north-western directions; and Norwegian detritus has been transported westward to the coasts of Norfolk and Yorkshire.

Russia in Europe, from the nature of its surface, cannot be supposed to afford many proofs of furrows grooves, and striæ on hard rocks; but on Lake Onega a hard greenstone and siliceous breccia are rounded off, grooved and striated on the northern face of a small promontory, the direction of the grooves and striæ being north and south, and the striæ are to be seen, through the transparency of the water, eight feet below its surface; they are also to be traced near the summit of a low hill. On the south side of that hill, however, no such traces of wearing or friction can be seen, "and thus," the authors say, "we had before us, on the edges of Russian Lapland, the very phænomenon so extensively observed by Sefström over Sweden, viz. a rounded, worn, and striated surface of the northern sides of promontories, whose southern faces are natural and unaffected by any mechanical agency."

M. Durocher visited the coasts of Sweden and Norway, in the neighbourhood of Christiania, last year, and discovered there many most remarkable instances of these furrows and striæ, detailed accounts of which he has given in the paper read before the Geological Society of France, in December, which I have already alluded to. He indeed describes effects of erosion on a much greater scale than I remember to have read of before; furrows so deep, that channels are a more appropriate term; as he himself has thought, for he calls them *canaux*. Both on the east and west coasts of the bay at the head of which Christiania is situated, from Gothenborg on the Swedish shore, and from Arendal, on the Norwegian, to Christiania, distances of 160 and 170 miles respectively, and especially among the islands that skirt the Norwegian coast, he observed the rocks worn into deep channels and furrows, or striated, in directions from north-west to south-east, and having their surfaces rounded and polished. These channels or furrows are of various dimensions; some from twenty-five to fifty centimetres (ten to twenty inches) in width, with a depth of from one and a half to two and three metres (five to ten feet). In a great number of instances the sides of the interior of these channels are grooved and striated in the direction of their longer axis. Sometimes they divide into two or more branches, which afterwards reunite into one. Many are rectilinear, but many are undulating, and bent in short waves. The axes of the channels and the striæ in their interior have the same general direction as the depressions of the neighbouring country. The north-western extremity of these channels, that is, the openings made where the eroding instrument entered, are somewhat wider than the rest of the channel, and are rounded off, polished, and striated.

Another very curious, and, as far as I know, a new class of facts has been described by M. Durocher. These furrows, he states, are frequently met with in horizontal lines *on the under side of overhanging rocks*, and he has met with instances of this description

along the Norwegian coast to beyond Drontheim, a distance from Gothenborg of more than 500 miles. One remarkable case he gives, that occurs to the north of Drontheim, where the furrows are cut horizontally in a pudding-stone rock of pebbles of granite and quartz, the hardest of which are cut through as clean as the softer argillaceous cement. The eroding tool has acted to the length of forty-five metres (about fifty yards), on a surface inclined from 45° to 50°, and with a breadth of from four to five metres (thirteen to sixteen feet). But my limits oblige me to refer you to the memoir itself, and to the report of the discussion to which it gave rise, for many most interesting facts, and some important views as to the causes of these remarkable phænomena*. For the same reason I can only very briefly allude to the descriptions contained in several parts of Mr. Lyell's 'Travels,' of the boulder formation, the erratic blocks, and the furrowed surfaces that are met with over a great part of the northern regions of North America, presenting many features identical with those of Northern Europe.

In Europe the boulder formation has not been traced farther south than 52° north latitude, but a similar kind of detritus, sand, clay, gravel, and rounded blocks of great size, cover a considerable extent of country in the neighbourhood of Boston, which is ten degrees farther south, or about the latitude of Valencia in Spain. It is not found within the range of the Alleghany Mountains; but blocks again appear on their western side, near the Ohio river, in latitude 40°, and some scattered blocks have reached Kentucky, the northern boundary of that state, in latitude 38½°. How far a boulder formation, erratic blocks and furrowed rocks extend beyond the valley of the St. Lawrence, we have yet to learn; but the scanty information we do possess leads us to infer that they exist on the shore of the Arctic Sea.

Near Boston the boulder formation has been pierced to a depth of more than 200 feet without the solid rock having been reached; and although mainly composed of the materials of neighbouring rocks, huge rounded blocks brought from a great distance rest upon them or are buried in them. Here, as in Russia and Denmark, we have a boulder formation composed of materials that have not been far-travelled, intermixed, in some degree, with, but more frequently covered by that of northern origin. An instance of this last occurs at Brooklyn, near New York.

In the United States, Canada, and Nova Scotia, where the gravel or drift has been removed, the rock immediately subjacent is very frequently furrowed and striated, and here and there flattened domes of smoothed rock (*roches moutonnées*) are met with. The furrows have been found in the New England Hills at all heights, even to as much as 2000 feet. In one place, on the summit of a high hill of sandstone, Mr. Lyell saw an erratic block of greenstone 100 feet in circumference. The erratic blocks and boulder formation have been transported southwards along the same lines as are marked out

* Bulletin de la Soc. Géol. de France, tome iii. p. 65.

by the direction of the furrows: in New England from N.N.W. to S.S.E.; in the valley of the St. Lawrence from north-east to south-west.

With regard to evidence of the age of the boulder formation of North America, I am not aware of any having been met with that connects it with a period so early as in Denmark; it contains in many places shells identical in species with those now living in the adjoining seas. The detritus in which the bones of Mastodon are buried at Big-Bone-Lick, in Kentucky, Mr. Lyell is inclined to believe to be more modern than the northern drift.

In the last number of the 'Edinburgh Philosophical Journal' are two valuable papers relating to erratic blocks, grooved surfaces, and the action of glaciers; the one by Mr. Maclaren, to which I have already referred, the other by Professor James D. Forbes. The paper of Mr. Maclaren describes grooves and striæ which he observed last summer on the rocks on each side of the Gare Loch, in Dumbartonshire, and these, together with blocks and an accumulation of loose materials resembling a terminal moraine, appear to indicate very clearly the former existence of a glacier in the space inclosed between the hills that bound the loch. He also observed numerous rounded blocks in the same locality, which could not have been produced by the same glacier, for they consist of granite, some of great size, as much as five feet in diameter, at various heights on the hills—one on the top of a hillock, 320 feet above the loch; and no granite, no parent-rock to which they can be traced is nearer than forty miles to the north. But between the localities where they now exist and that parent-rock there are ridges, over which they must have travelled, that are 1500 feet above the present sea-level. This then is a case analogous to that of the Valdai Hills in Russia, on the southern flanks of which blocks of Scandinavian granite are scattered, indicating that these hills, and in like manner the summits of the barrier north of Gare Loch, were a sea-bottom, upon which the blocks were dropped from floating icebergs; that sea-bottom being subsequently raised, to form the existing land.

The principal object of Professor Forbes's paper is to describe the topography and geological structure of the Cuchullin Hills in Skye. He gives us much new and interesting information respecting the igneous rocks, of which they are composed, particularly that comparatively rare variety, hypersthene rock: but he also describes these same rocks as being furrowed and polished in several of the valleys, but especially in the valley of Coruisk, the furrows there radiating from a centre to the sea-shore, and, in his opinion, they demonstrate in as clear a manner as the subject admits of, the former existence of a glacier in that locality. All will admit that the opinion of Professor Forbes on this subject is one in which we may place entire confidence. The hypersthene rocks "are smoothed and shaven in a direction parallel to the length of the valley wherever their prominent parts are presented towards the head of the valley; but towards the sea, they are often abruptly terminated by craggy surfaces, showing the usual ruggedness of the natural fracture of

the rock, and exhibiting the phænomenon of *Stoss Seite* and *Lee Seite*, so often described in the Scandinavian rocks."

"When the same rock is traversed by claystone veins, or by veins of crystallized hypersthene and magnetic iron, these various parts of such different hardness are all uniformly shaven over, in conformity with the general form of the mass to which they belong. This presents a striking analogy to the phænomena of polished rocks in the Alps, where the quartz veins are cut off parallel to the surface of the bounding felspar. . . . . The furrows are not confined to the entrance of the valley, but extend to the upper part of it, and to a great height above its level, particularly on the west side, where the faces of these almost vertical cliffs of adamantine hardness are scored horizontally, as potter's clay might be by the pressure of the fingers, or like the moulding of a cornice by the plasterer's tool."

The question naturally arises, at what period were these valleys in Dumbartonshire and in Skye occupied by glaciers? That they were so after the land had been formed into the present mountains and valleys is obvious; but that defines no particular period. We have in the Gare Loch two distinct classes of phænomena, which could not have been produced either by the same agents or at the same time. We have proof of the action of sub-aërial glaciers; we have also proof that there are erratic blocks that could not have been brought into their present position unless the ground on which they rest had been submerged: they were dropped, it is most reasonable to suppose, from icebergs floating in a sea, and arrested by elevations in the sea-bottom. During such submergence there could be no glaciers in the valleys of Gare Loch or Coruisk. Are we to suppose that after these valleys had been occupied by a glacier, and the erosions had been made, the land sank down, continued for a long interval as a sea-bottom, during which time the glaciers melted away, and that the land again emerged, bearing the erratic blocks upon it? The subject is one of vast difficulty; but the phænomena evidently involve great changes in the condition of the land, and consequently, perhaps, in the climate of that region.

It is an important feature in the history of the boulder formation, that the mode of its accumulation, and the direction of the channels, furrows and striæ worn in the rocks, indicate a force coming from the north between N.W. and N.E. The worn and polished surfaces of so many rocks facing the north, while their rugged unworn surfaces point to the opposite direction, are farther proofs of the same movement. The travelled rounded boulders and detritus from the middle of Sweden and Norway southward must therefore have been derived from land existing north of that latitude.

Submarine currents are by many geologists supposed to have been the moving power; and it is also said, that the detrital matter they hurried along smoothed and polished the rocks they met with in their progress, and graved the furrows and striæ. We as yet know little of the existence, at great depths, of submarine currents, or of their power of transporting heavy materials. Sir R. Murchison, referring to the generation and power of what Mr. Scott Rus-

sell calls a wave of the first order, or "the wave of translation," and to the application of Mr. Russell's researches and theory by Mr. Hopkins, in his paper "On the Elevation and Denudation of the district of the Lakes of Cumberland and Westmoreland *," considers that all the phænomena of the boulder formation and drift of Northern Europe (not including the erratic blocks) may be accounted for by the action of such waves. But a sudden paroxysmal movement of the bed of the sea is a necessary condition for the production of a wave of translation. Mr. Hopkins says, "If the elevation were sufficiently gradual, no sensible wave would result from it; but if it were *sudden*, the surface of the water above the uplifted area would be elevated very nearly as much as the area itself, and a *diverging* wave would be the consequence;" and that "there is no difficulty in accounting for a current of twenty-five or thirty miles an hour, if we allow of *paroxysmal elevations* of from 100 to 200 feet;" and he adds, that "if the extent of country be considerable, the elevation might occupy *several minutes*, and still produce the great wave above described." It is to be observed that the wave would be *diverging*, and therefore the currents would not be limited to one direction. But however great the power of transport of the sudden wave might be, its action would be transient, and we must therefore suppose, either that the whole phænomena were produced by one sudden elevation, or that there was a succession of paroxysms. Whether such sudden violent transport, such tumultuous hurrying-along of the blocks, gravel and sand, be consistent with the forms and arrangements of the detrital matter, the long "trainées," "the widely spread and finely laminated sands," and the included fragile shells, can only be determined by special observations directed to such an inquiry. It does not appear at all consistent with the formation of the detritus of local origin, that which constitutes so great a part of the boulder formation over the whole northern region, and which seems to indicate a long-continued action over the same ground. We ought, besides, to have some independent evidence of paroxysmal action in the same region; whereas there is the strongest proof of gradual upheavals: take, for example, the whole continent of European Russia, which exhibits scarcely any disruption, and which, Sir R. Murchison is of opinion, was elevated *en masse*.

But we must go further back in our inquiry; before the wave of translation was generated. Whence the detrital matter which the wave transported? Are we to suppose that the same paroxysmal movement broke up and shattered to fragments the bottom of the sea, and that it was these fragments which the transient wave transported and rounded into boulders? Or is it more reasonable to suppose, that the materials of the detritus must have been derived from pre-existent land, the rocks of which were broken by glacial and atmospheric action, as rocks now are, to be afterwards rolled, rounded and polished by currents of water; as they unquestionably must have been, however the currents may have been produced?

* Proc. Geol. Soc. vol. iii. p. 757.

Then as to the power of such currents, transporting hard bodies, to produce the furrows and striæ, I should be disposed to refer to the *physicien*, to him conversant with the laws of mechanical philosophy, the questions whether rounded blocks and gravel, *moving in water*, passing over rocks, would be capable of producing on them these deep furrows and striæ; or whether it is not more probable that they were worn by angular fragments of rock held fast in ice, and pressed, as the current floated the iceberg, against the opposing rock, with a vast force derived from the weight of the mass?

We learn from the 'Magazine of Natural History' of last September, that letters had been received the preceding month from Mr. Harry Goodsir, attached, as Naturalist, to the Arctic Expedition under the command of Sir John Franklin, dated from Disco in Baffin's Bay the 7th of July last; and it is stated that "Mr. Goodsir is making minute observations upon the ice of the bergs, and as he purposes continuing them throughout the voyage, there can be little doubt of his arriving at valuable conclusions." It is added, "We also find some observations upon the action of floating ice upon the *granitic* shores of the islands. *All the rocks below high-water mark, and some considerably above it, are rounded off into long irregular ridges with intervening hollows by the half-floating masses of ice.*"

Palæontology.

This great department of Geology is now cultivated with so much industry by so many naturalists in Europe and America, that scarcely a month elapses without some valuable additions to our knowledge. It is not possible for me to do more than briefly refer to some of the more important of those which I have had an opportunity of becoming acquainted with.

At the last Meeting of the British Association at Cambridge, Professor Edward Forbes made an interesting and important communication to the Natural History Section, in which he pointed out a connexion of the present distribution of plants with geological changes which took place during the later tertiary periods. He maintains, for example, that the existing flora of Britain belongs, not to the present epoch only, but is composed in part of the remains of the floras of the pliocene and post-pliocene periods. He considers that certain peculiarities of the vegetation of the west of Ireland depend on an ancient geological connexion with the Asturias; those of the Scottish and Welsh mountains on the migration of plants from Scandinavia during the glacial period, and the subsequent upheaval of the land, and consequent change of climate; whilst the great mass of the British flora migrated across the upheaved bed of the Pleistocene sea. He further holds, that the determination of the date of the migrations of terrestrial plants and animals will eventually aid in fixing the periods of many geological events.

In the year 1828, M. Elie de Beaumont published in the 'Annales des Sciences Naturelles' an account of some observations he had

recently made at Petit-Cœur, a village in the Tarentaise, east of Chambery; where he had seen resting on talcose gneiss and hornblende schist, a series of sedimentary beds, which prevail over a great extent of that country, the lowest of which, a micaceous sandstone alternating with a black slaty rock, is surmounted by a bed of fissile argillaceous limestone containing Belemnites, and this last passes insensibly into a black slaty clay containing impressions of plants identical in species with some of those belonging to the true coal formation. M. de Beaumont concludes his detailed description in these words:—"Il me parait donc incontestable que le système de couches qui, à Petit-Cœur, contient les Belemnites et les impressions végétales, et qui s'enfonce sous toutes les autres couches non-primitives de cette partie des Alpes, *appartient à la formation du lias*." The plants were carefully examined by M. Adolphe Brongniart, and in an accompanying memoir descriptive of them he states, "que l'identité la plus parfaite existe entre ces plantes et celles du terrain houiller, tandis qu'il n'y a aucun rapport entre elles et celles qui se trouvent habituellement dans le lias, ou dans les terrains oolitiques." He enumerates among others of Petit-Cœur, *Neuropteris tenuifolia*, found at Liege and Newcastle; and *Pecopteris polymorpha*, one of the most common in the coal-fields of France.

At the meeting of the Geological Society of France at Chambery in autumn 1844, an account of which we have received since our last Anniversary*, the attention of the members was directed to this most remarkable fact, in a memoir by M. Rozet; and afterwards, several who attended the meeting visited Petit-Cœur. The observations of M. Elie de Beaumont and M. Adolphe Brongniart were confirmed in every particular; they found abundance of the vegetable remains, and of Belemnites below them. The report farther states:—"Il a été évident aussi, pour tous les membres de la Société, que l'on ne peut aucunement admettre l'explication d'un plissement qui aurait rapproché les fossiles de deux formations et produit une alternance apparente entre les couches à Belemnites et les couches à empreintes. Ce sont les mêmes schistes et la même formation qui renferment ces deux genres de fossiles que l'on avait cru pendant longtemps appartenir à des époques géologiques très éloignées l'une de l'autre." M. Sismonda, who was present, stated, that in another locality he had found Ammonites in a prolongation of the same bed; and in reply to M. Agassiz, also present, affirmed, that he had found this bed containing Belemnites and coal-plants over an extent of from twenty-five to thirty leagues. We have thus the same species of plants continuing to exist throughout the whole Carboniferous, Permian and Triassic periods, and into that of the lower portion of the oolite age. I need not say how important a bearing this remarkable fact has on the theories of climate, and of the prevalence of an atmosphere loaded with carbonic acid gas during the Carboniferous period.

M. Adolphe Brongniart, in his memoir above cited, thus accounts

* Bulletin de la Soc. Géol. de France, vol. i. new ser. p. 601.

for the anomalous position of these coal plants; "À l'époque où la formation du lias se déposait en Europe, notre globe présentait très-probablement deux régions très-diverses par leur climat et par les végétaux qui y croissaient. L'une comprenait l'Europe et peut-être toute la zône tempérée, et était habitée par des végétaux fort différens de ceux qui y croissaient à une époque plus reculée, et qui avaient donné naissance aux couches de houille; l'autre s'étendant sans doute sur les parties plus chaudes du globe, était encore couverte des mêmes végétaux qui, dans des temps plus anciens, avaient habité la région européenne, et formé les dépôts houillers. Les végétaux de cette partie du globe pouvant dans certaines circonstances, être transportés dans les régions plus tempérées, auraient donné lieu à ces anomalies apparentes que présentent les terrains d'anthracite des Alpes qui, d'après les observations géologiques et zoologiques, appartiennent à l'époque de formation du lias, et dont les végétaux sont cependant les mêmes que ceux du terrain houiller." This theory therefore admits that the same species of plants existed through the whole series of ages that passed from the time of the deposition of the carboniferous series to that of the lias; that they and Belemnites were co-existing, but in different regions. It is not very easy to conceive how such delicate vegetable bodies should be drifted the vast distance between a tropical and temperate zone, to form parts of thin continuous strata thousands of square miles in extent, in successive layers of great thickness on the same spot, in the depths of the sea.

It is extremely improbable that this case in the Tarentaise is a solitary one; future researches will probably bring to light other instances of a similar kind. May not these facts be an extension to plants of the recently advanced doctrine regarding animals, that species which have had a wide range in space have also had a long duration in time? or as it is expressed by those who first brought it forward,—"That the species which are found in a greater number of localities and in very distant countries are almost always those which have lived during the formation of several successive systems." The attention of geologists, I believe, was first directed to this highly important observation by Viscount d'Archiac and M. de Verneuil, in their joint paper "On the Fossils of the older Deposits of the Rhenish Provinces," read before this Society in December 1841; and while these distinguished geologists announced the law as applicable to the oldest fossiliferous beds, Professor Forbes has shown the extension of it to existing species. He found "that such of the Mediterranean testacea as occur both in the existing sea and in the neighbouring tertiaries, were such as had the power of living in several of the zones in depth, or else had a wide geographical distribution, frequently both." He adds, "The same holds true of the testacea in the tertiary strata of Great Britain. The cause is obvious: such species as had the widest horizontal and vertical ranges in space, are exactly such as would live longest in time, since they would be much more likely to be independent of catastrophes and destroying influences than such as had a more limited distribution." Now we know

that the same species of plants are found in the coal-fields belonging to the palæozoic carboniferous rocks of Europe and of North America, and in regions with differences of more than thirty degrees of latitude; and therefore they may have been able to live through the many vicissitudes of condition of the earth's surface that must have occurred between the Carboniferous and Liassic periods.

The plants from the Permian system of Russia, collected by Sir R. Murchison and his fellow-travellers, have been described by Mr. Morris, and further illustrated by the remarks of M. Adolphe Brongniart. The species are few, not exceeding sixteen in number. Three of these—*Neuropteris tenuifolia, Lepidodendron elongatum* and *Calamites Suckowii*—are pronounced by M. Brongniart to be identical with plants of the coal formation. The remainder are peculiar (as far as is hitherto known) to the Permian system. All the *genera* are common to this and to the carboniferous series; the genera *Odontopteris, Noeggerathia* and *Lepidodendron* had been hitherto supposed peculiar to the coal-measures. Altogether, the Permian flora is evidently much more similar to that of the carboniferous system than to any other: it has no affinity to that of the Grès bigarré, or of the Jurassic system.

Mr. Morris has likewise described the fossil plants brought by Count Strzelecki from the coal-fields of New South Wales and Van Diemen's Land. Unfortunately the materials were very scanty, the number of species being only eight; and it is singular, that of this number four are from the coal-field of New South Wales, and four from that of Van Diemen's Land, no one species having been found common to the two. Both these Australian coal-fields are very remarkably distinguished from those of Europe and North America by the entire absence of *Stigmariæ, Sigillariæ, Lepidodendra,* and *Calamites.* In this respect they agree with the coal formation of Burdwan in Northern India, to which indeed they have other points of striking similarity in the character of their vegetable remains. The *Glossopteris Browniana* is actually common to the coal formations of New South Wales and of India, and the *Pecopteris australis* of the former country comes very near to the Indian *P. Lindleyana.* The flora of the coal-fields of Australia has likewise a striking similarity to that of our Yorkshire oolites. *Glossopteris Browniana* is nearly allied to *Glos. Phillipsii, Pecopteris australis* to *P. Whitbiensis,* and *Pecopteris alata* to *P. Murrayana.* It is possible that the coal of Australia and of Northern India may really belong to the Jurassic system.

In the 'Geology of Russia,' a work I have already so often referred to, there is an immense mass of valuable contributions to palæontology, by different distinguished naturalists. The following are the parts which relate to the Invertebrata:—

1. A very elaborate and important essay by Mr. Lonsdale on the palæozoic Corals of Russia, abounding in minute details of structure, deserving the attention of every one engaged in the study of that class of organic bodies.

2. A full synopsis of the palæozoic Radiata, Articulata and Mollusca, by M. de Verneuil. The species are all admirably described, and full details of great interest are given respecting their affinities, synonyms, and distribution. A great number of new and curious forms are made known for the first time. In that part which treats of the Brachiopoda, M. de Verneuil has given the results of a critical investigation of the genera, accompanied by tables of characters of the greatest value. He has constituted a new genus, *Siphonetreta*, for the reception of certain very curious fossils, which, while presenting much of the form of *Terebratulæ*, are really allied to *Orbiculæ*, and have the same corneous texture of shell. Among the palæozoic *Acephala*, he has described a well-marked species of *Astrea*, a genus hitherto having only doubtful claims to such high antiquity. Among the *Gasteropoda*, *Ianthina* for the first time appears as a palæozoic genus.

In the account of the *Radiata* are interesting descriptions and comments on the Russian species of *Cystideæ*. Among the *Articulata* is the genus *Fusulina*, a foraminiferous animal abounding in certain beds of carboniferous limestone in Russia. Hitherto, traces of such animals in such ancient beds have been few and imperfect.

3. The Jurassic, cretaceous, and tertiary mollusca are described in full detail by M. d'Orbigny, and their synonyms carefully elaborated,—a service for the rendering of which we cannot be too thankful, since duplicate names have accumulated to a most confusing extent. As an instance, it may be mentioned that M. d'Orbigny enumerates as synonyms of the *Ammonites Jason* of Zieten, no less than fourteen distinct names.

The plates throughout are admirable.

The history of fossil radiate animals has received one of the most important additions ever made to it, in the memoir of M. von Buch on the *Cystideæ*; a memoir of the greatest value to the naturalist, since it furnishes him with an elaborate and philosophical exposition of the organization and affinities of a group of fossil animals hitherto misunderstood, and which fill up a blank in the series of Radiata. As these fossils are now known to be by no means unfrequent in the British palæozoic strata, though they have hitherto attracted but little attention, the study of the paper, itself a model of palæontological description, will well repay the attention of geologists. They will find it at full length, translated by Professor Ansted, in the last number of our Journal; and I may adduce it as an instance of the valuable assistance which we afford to the geologists of this country, by devoting a portion of our Quarterly publication to original foreign memoirs; for how few there are who can have an opportunity of seeing the 'Transactions of the Berlin Academy,' to say nothing of those who do not read German!

M. Agassiz, that most indefatigable of living naturalists, besides his important contributions during the last year in that department

in which he is universally acknowledged to occupy the highest rank, has commenced a new series of essays under the title of '*Iconographie des Coquilles Tertiaires reputés identiques avec les espèces vivantes, ou dans différens terrains de l'époque tertiaire.*' In the preface to the first part he announces his views and object. He says that he has been long convinced that the greater number of identifications of tertiary shells with those of other tertiary epochs, or with recent species, are incorrect. From his investigations he is led to maintain, 1st, that notable differences exist between living and tertiary species; and 2ndly, that in the tertiary formations the different stages present distinct faunæ. He opposes classification founded on *per-centages* as purely artificial, and attributes the errors to the mistaking analogues for true identifications. He holds that each geological epoch is characterized by a distinct system of created beings (the results of a new intervention of creative power), including not only different species from those of the preceding system, but also new types. At the same time he admits that the "reiterated intervention of the creative power" does not necessarily and absolutely imply a specific difference between the beings of different deposits. He holds however the probability of such a difference existing, and his object in this 'Iconographie' is to prove that such difference has been overlooked. He goes the length of saying, that, even when species are, so far as the eye can judge, identical, they may not be so. "Perhaps," he says, "there may exist species so nearly allied, as to render it impossible to distinguish them; yet even that would not be to my eyes a proof of their identity; it would only prove the insufficiency of our means of observation:" and further, "the animals might differ though the shells are like."

In the special part of his essay, M. Agassiz proceeds on the position that the law of variation is not the same in all classes, families and genera; and selects his examples from certain genera of Acephalous Mollusca in which the characters are very constant, viz. *Artemis*, *Venus*, *Cytherea*, *Cyprina* and *Lucina*, on thirty-one forms of which genera, considered by him as distinct species, he gives full comments and valuable details. One species only among them, the *Cyprina islandica*, he admits to be at the same time recent and fossil.

M. Agassiz introduces the same doctrine in his Monograph of the Fishes of the Old Red Sandstone. Thus he says, at page xi, that the characteristic fossils of each well-marked geological epoch are the representatives of so many distinct creations, and affirms that he has demonstrated "*pour un nombre assez considérable d'espèces*," that the presumed identifications are exaggerated approximations of species resembling one another, but nevertheless specifically distinct.

Whether species of Mollusca hitherto deemed common to two or more of the tertiary periods be really, as M. Agassiz affirms, distinct, is a doctrine that must await the concurrence of experienced conchologists before it can be made the means of overthrowing present generalizations, and the basis of new ones. With regard to the Mammalia, certain eocene forms have been repeatedly recognised in

miocene strata, and the continental miocene Mastodon has been satisfactorily determined as a fossil of our older pliocene (Norwich Crag). But M. Agassiz is peculiarly unfortunate in citing Dr. Falconer and Major Cautley (p. xi) as supporting, by their discoveries of fossil animals in the Sub-Himalayan Mountains, his views as to marked distinctions of the tertiary fauna, since they have done more than any other palæontologists to prove the progressive and undistinguishable blending of eocene into miocene, and this into pliocene, by the mammalian fossils, and have shown that some species of reptiles actually exist at the present day which were coeval with the Himalayan Anoplothere, Mastodon and Hippopotamus.

The attention of several distinguished naturalists has lately been directed to the investigation of the structure and classification of Trilobites. A valuable work on these singular extinct crustacea has been lately given to the world by Professor Burmeister, who is now revising an English translation of it, to be published by the Ray Society. In this work there is a systematic arrangement of all the species known to the author, and there are dissertations of great value on their organization. M. Emmerich has also published a very important memoir on the structure of Trilobites, a translation of which has lately appeared in Mr. Taylor's 'Scientific Memoirs.' In Sweden, Professor Löven, a naturalist distinguished for his researches among the invertebrate animals, has commenced the investigation of the Trilobites of that country with great success. His papers may be found in the Proceedings of the Swedish Academy for 1844 and 1845. All the memoirs now enumerated are illustrated by excellent plates. Lastly, in the 'Geology of Russia' will be found an interesting note on the affinities of Trilobites, by Professor Milne Edwards.

In what I have said of the accessions during the last year to our knowledge of the Devonian rocks, I have referred to the Monograph by M. Agassiz of the Fishes of the Old Red Sandstone, which those most capable of appreciating its value consider as one of his most important works; and I have reason to know that he himself views it in that light. I again refer to it in this place on account of some peculiar views there developed which I do not find altogether assented to by those whose judgements on this subject are much looked up to.

M. Agassiz states, p. xxx, "que les poissons de l'Old Red représentent, *par leur structure toute particulière*, l'age embryonique du règne des poissons." A part of the peculiar structure which he especially dwells upon is, "le développement extraordinaire que présente le système cutané;" but he acknowledges that "malheureusement nous n'avons pas encore des termes de comparaison avec les poissons de la création actuelle assez nombreux pour apprécier la valeur de ces caractères." Another feature of the peculiar structure which he points out is the continuity of the vertical fins. This

character, however, Sir Philip Egerton and Professor Owen inform me, is only of partial application; the family of *Cephalaspides* he does not cite, but in *Coccosteus*, the sole form of Old Red fishes in which vertical fins have been observed, the distance between them is considerable. In the *Dipterians*, *Dipterus* has these organs very close, but in *Diplopterus* and *Osteolepis* they have considerable intervals between them. *Diplopterus* moreover occurs in the coal-measures. In the *Cœlacanths* the fins of *Glyptolepis* are very near each other, but this family runs into the chalk. In the *Acanthodians* the fins are quite distinct, and *Acanthodes* is found in the coal-measures. There are also recent fishes with their vertical fins quite as little distinct as in the most exaggerated of the Old Red. Neither is the heterocerque tail a character peculiar to the fishes of the Old Red, for all the fishes older than the lias have this form, as have the Sturgeons of the present day; and it is perhaps more important to find, that certain highly characteristic genera of the Old Red, for example, *Pterichthys*, *Pamphractus* and *Coccosteus*, did not possess the heterocercal tail.

Another character, viz. the flattened form of head, is not peculiar to the Old Red, for the *Siluridæ* and other recent fishes have this character equally prominent. Then the non-development of the vertebral column is found in the Sturgeon, Lamprey and other recent fishes. Persons seeking for support to the theory of progressive development might, on a hasty perusal of this work, find sentences in favour of their views; but the above facts are irreconcilable with the theory as ordinarily promulgated, and it would be a perversion of M. Agassiz's undoubted opinions to quote detached sentences from his writings in support of that doctrine. They will find for instance, at p. 23, a rectification of the error committed by the ingenious Hugh Miller, in describing the jaws of the *Coccosteus* as being vertical, like those of crustacea, and thence inferring that "it seems to form a connecting link between two orders of existences;" M. Agassiz having proved that they are horizontal, and move vertically, as in other true fishes. Then there are four species of Sharks of the Cestracion division in the Devonian rocks of Russia, and the squaloid fishes of the present day offer the highest organization of the brain and of the generative organs, and make in these respects the nearest approach to the higher vertebrate classes.

The work of Professor Owen on the fossil remains of Mammalia and Birds found in the British Islands, which has been for some time in course of publication, is now completed, the concluding part having been published within the last few days. This valuable contribution to palæontology, in which it is the purpose of the author "to deduce from these remains, by physiological comparisons, the living habits of the extinct species, to trace out their zoological affinities, and to indicate their geological relations," is another gift in the last year for which geologists are indebted to the British Association. Professor Owen in his preface states, that the special researches which have

enabled him to fulfil in any degree the above-mentioned design, were begun by the desire, and have been carried on chiefly by the liberal aid of that body.

The concluding part contains a very interesting and instructive introduction, which will enable the reader to follow with far greater pleasure, and more fully to appreciate the value of the special details which follow. He begins by pointing out that first trace of the creation of mammalian quadrupeds which was discovered in the Stonesfield slate of the oolitic series, and it was certainly a most fortunate accident which brought these minute bones within the sight of a geologist. It is a very remarkable circumstance, that all the researches of geologists, multiplied as they have been since that discovery was made, have not yet brought to light another fragment of the same order of animals, throughout the vast series of deposits, the immense duration of time, that intervened between the Stonesfield slate and the eocene tertiary deposits; notwithstanding that there are indubitable proofs of the existence during that interval of extensive continents, of forests growing on that land, of its being tenanted by other races of animals, and that birds and pterodactyls spread out their wings in the air above it.

The land that supported the mammalia whose remains are found in the eocene deposits of our island must have been submerged, and must to a great extent have remained so during the miocene period, when the adjoining continent was inhabited by the animals whose remains have been disinterred there from the deposits of the miocene age; for it is in pliocene and post-pliocene deposits that the mammalian remains in the British Islands next present themselves. There is the most conclusive proof that the animals lived and died, generation after generation, for a long succession of years, in the land where their remains are now found; evidence which completely "refutes the hypothesis of their having been borne hither by a diluvial current, from regions of the earth where the same genera of quadrupeds are now limited. The very abundance of their fossil remains in our island is incompatible with the notion of their forming its share of one generation of tropical beasts drowned and dispersed by a single catastrophe."

The author ably discusses the question how the various members of that ancient fauna came into this island. Other and independent geological proofs show that the British Islands were united with the continent when it received its pliocene mammalia, and the zoologist finds the known habits and powers of these mammalia to be in accordance with that configuration of the land. He then considers the no less important question, although it is one more difficult of solution—by what processes they became extinct? The subterranean movements which separated our islands from the continent, and submerged other parts of these islands, must have produced such changes in the means of subsistence and powers of migration of these animals as must have been one great cause of their diminution and eventual extinction; the loss of a sufficient supply of vegetable food for the greater herbivorous quadrupeds, and, by their diminished numbers,

the want of support for the larger carnivora which preyed upon them. He enumerates other causes which must have operated for a long period before the agency of man aided the work of extinction. He adduces many most curious and interesting particulars in illustration of the laws by which the geographical distribution of the mammalia of the pliocene and post-pliocene periods generally appear to have been determined; showing that, "with extinct as with existing mammalia, particular forms were assigned to particular provinces, and, what is still more interesting and suggestive, that the same forms were restricted to the same provinces at the pliocene period as they are at the present day."

In this work eighty species of British fossil Mammalia are described, of which the following (forty-two in number) were either originally determined by the author as new species, or were first recognised by him as occurring in a fossil state. They were for the most part described in the publications of this Society.

Amphitherium *Broderipii*.
Arvicola *agrestis*.
——— *pratensis*.
Balæna *affinis*.
——— *definita*.
——— *emarginata*.
——— *gibbosa*.
Balænodon *physaloides*.
Bison *minor*.
Bos *longifrons*.
Cervus *Bucklandi*.
——— *Tarandus*.
Chæropotamus *Cuvieri*.
Coryphodon *eocenus*.
Dichobune *cervinum*.
Equus *plicidens*.
Felis *pardoides*.
Hyracotherium *leporinum*.
——— *cuniculus*.
Lagomys *spelæus*.
Lophiodon *magnus*.
Lophiodon *minimus*.
Lutra *vulgaris*.
Macacus *eocenus*.
——— *pliocenus*.
Machairodus *latidens*.
Meles *taxus*.
Palæotherium *magnum*.
——— *crassum*.
——— *minus*.
Palæospalax *magnus*.
Phascolotherium *Bucklandi*.
Phocæna *crassidens*.
Physeter *macrocephalus*.
Rhinolophus *ferrum-equinum*.
Sorex *vulgaris*.
Strongyloceros *spelæus*.
Talpa *vulgaris*.
Trogontherium *Cuvieri*.
Ursus *priscus*.
Vespertilio *vulgaris*.

Of the eighty species described in this work,
Three are of Oolite antiquity;
Twenty from Eocene tertiary strata;
Five from the Miocene Red Crag;
Fifty-two from the older and newer Pliocene freshwater and drift formations.

Of the newer Pliocene species of fossil Mammalia, seventeen became extinct before the historic period, viz.—

Macacus pliocenus.
Palæospalax magnus.
Ursus priscus.
——— spelæus.
Hyæna spelæa.
Felis spelæa.
Machairodus latidens.
Trogontherium Cuvieri.

Lagomys spelæus.
Elephas primigenius.
Rhinoceros tichorhinus.
——— leptorhinus.
Equus plicidens.
Hippopotamus major.
Megaceros Hibernicus.
Strongyloceros spelæus.
Cervus Bucklandi.

Five species came down to the age of tradition or history, and have been extirpated in England, viz.—

Canis lupus, Wolf.
Castor Europæus, Beaver.
Cervus Tarandus, Reindeer.
Bison priscus, Aurochs.
Bos primigenius, or great Urus. This species is also extinct on the continent.

Twenty-six of the Mammalia whose fossil remains testify to their co-antiquity with the Mammoth, still exist in England as well as on the continent of Europe, viz.—

Vespertilio noctula, } Bats.
Rhinolophus ferrum-equinum, } Bats.
Sorex, Shrew, three species.
Meles taxus, Badger.
Putorius vulgaris, Polecat.
——— ermineus, Stoat.
Lutra vulgaris, Otter.
Canis vulpes, Fox.
Felis catus, Wild Cat.
Mus rattus, Black Rat.
—— musculus, Mouse.
Arvicola, Vole, three species.
Lepus timidus, Hare.
Lepus cuniculus, Rabbit.
Equus caballus, Horse.
——— asinus, Ass.
Sus scrofa, Hog.
Cervus elaphus, Red Deer.
——— capreolus, Roe.
Capra hircus, Goat.
Bos longifrons (probable source of the Highland cattle).
Physeter, Sperm Whale.
Balænoptera.
Balæna mysticetus, Whalebone Whale.

You cannot but remember the great interest that was excited when Dr. Royle, in March 1836, communicated to this Society a paper by his friends Captain Cautley and Dr. Falconer, then resident in India, on the remains of Mammalia found in the Tertiary formations of the Sewalik Mountains, at the southern foot of the Himalayas, between the Sutlej and the Ganges; discoveries deemed so important, that the Council, at the following anniversary, awarded a Wollaston Medal to each of these gentlemen. Besides the paper by Captain Cautley, published in the fifth volume of our 'Transactions,' numerous details respecting these discoveries are contained in the 'Asiatic Researches,' and in the 'Journal of the Asiatic Society of Bengal.' A magnificent donation of these remains, contained in more than two hundred chests, was made by Captain Cautley to the British Museum, and a work of immense labour and research has been undertaken by Dr. Falconer, to describe, in conjunction with his friend, now Major Cautley, these very interesting remains. Her Majesty's Government and the Directors of the East India Company have supplied funds in aid of the successful progress of the work. The first part has just appeared; it bears the title of '*Fauna*

Antiqua Sivalensis,' and consists of twelve folio plates, and sixty-four pages of 8vo letter-press. Nothing has ever appeared in lithography in this country at all comparable to these plates; and as regards the representations of minute osseous texture by Mr. Ford, they are perhaps the most perfect that have yet been produced in any country.

The work has commenced with the Elephant group, in which, they say, "is most signally displayed the numerical richness of forms which characterizes the Fossil Fauna of India," and the first chapter relates to the PROBOSCIDEA—Elephant and Mastodon. The authors have not restricted themselves to a description of the Sewalik fossil forms, but they propose to trace the affinities, and institute an arrangement of all the well-determined species in the family. They give a brief historical sketch of the leading opinions which have been entertained by palæontologists respecting the relations of the Mastodon and the Elephant to each other, and of the successive steps in the discovery of new forms which have led to the modifications of these opinions. They state that the results to which they themselves have been conducted, lead them to differ on certain points from the opinions most commonly entertained at the present day respecting the fossil species of Elephant and Mastodon. As they differ in their conclusions from those of Cuvier, De Blainville and Owen as to specific differences, you will readily conclude that the proof they adduce rests upon nice distinctions in anatomical structure; to enter upon which would be quite unsuitable on the present occasion, by even the most competent to judge of questions in which such high authorities disagree.

CONCLUSION.

Although this Address has extended to so great a length, those who are actively alive to what is going on in the several departments of Geology will have found many important works of the past year unnoticed, many topics of interest left untouched. This would not have been the case to so great an extent, if I had had more time at my disposal. Even with the opportunities I have had, I might have briefly noticed a greater number of books published in our own and in foreign countries, and memoirs contained in Journals and Transactions; but I confess to yielding to an inclination to dwell upon topics that have more particularly attracted me in my past geological studies.

It is highly gratifying to see so much activity in the cultivation of our science in almost every part of the civilized world; and still more satisfactory to observe, that it has been for some time past pursued in a better spirit, with a disposition to greater accuracy and rigour in investigation, and with a more strict adherence to the rules of philosophical inquiry. When we contrast the state of Geology now with what it was when this Society was established, or compare the then limited extent of our knowledge of Palæontology with the wide range it now takes, and when we think of the crude hypotheses and hasty

generalizations, founded on the most scanty and imperfect observations, which were then misnamed science, we may well look back with satisfaction to the work of the last thirty years, to which this Society has contributed no inconsiderable share.

It has hitherto too frequently happened that geologists have dealt with important questions of physics, chemistry, comparative anatomy, zoology, or botany, without an adequate acquaintance with the principles and known laws of the science essentially involved in the question; now, unless our conclusions will bear the test of the most strict examination by those who are acknowledged authorities in the particular science, it is obvious that we cannot make any secure progress. The study of Geology, more perhaps than that of any other branch of natural science, has a tendency to create a disposition to theorize; this disposition, however, if kept within due bounds, is rather to be encouraged than repressed, for it has often proved a stimulus to accurate observation; and to arrive at a knowledge of a true theory of the earth, is, in truth, the great aim of our inquiries. But we must carefully guard against the error which the earlier geologists too frequently fell into, of quitting the sober path of inductive philosophy, and wandering into the regions of imagination. We must indulge in no theory that is not in accordance with laws of nature of which we have had experience, or which may be fairly inferred from that experience, although the operations we seek to explain may have been on a greater scale than any of which we have certain knowledge. The cautious and accurate Playfair was wont to inculcate upon those who studied in the school of Hutton, the warning of the noble aphorism with which Bacon opens his great work, the 'Novum Organum,'—an aphorism which every geologist will do well to bear in mind when he ventures to theorize on causes:—"*Homo, naturæ minister et interpres, tantum facit et intelligit, quantum, de naturæ ordine, re vel mente observaverit; nec amplius scit, aut potest.*"

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

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1. *Notice of the Fossils of the Palæozoic beds of the province of* ASTURIAS, *in the North of* SPAIN. By M. E. DE VERNEUIL and the COUNT D'ARCHIAC.

(From the 'Bulletin de la Soc. Géol. de France,' 2me Ser. tome ii. p. 448.)

[The subjoined extract forms the Appendix to a memoir read before the French Geological Society on the 19th of May, 1845, entitled "Researches concerning some of the rocks which constitute the province of the Asturias," by M. Adrien Paillette. M. Paillette describes successively, but briefly, the position and localities of the principal rocks, some of which he found to resemble very closely the beds of the same age in Brittany and Normandy. These rocks include Silurian, both lower and upper, Devonian, and Carboniferous strata, the latter containing important beds of workable coal. The carboniferous beds are greatly disturbed and dislocated, and the author proposes to continue their investigation in greater detail before publishing any general conclusions.—ED.]

OUR knowledge of the faunas of the various departments of the Palæozoic series of formations is not yet sufficiently complete, or deduced from observations of a sufficient degree of generality, to enable us to determine the age of any one of them by the presence of a single species of fossil; but this is not the case when we have before us a group of fossils from the same locality, obtained from beds whose mutual relations are well established. The following list, therefore, of the organized bodies obtained by M. Paillette from the deposits which he has so well studied and described, will enable us to draw certain conclusions, tolerably definite, as to the period of their deposit, by comparing them with what we already know with regard to other parts of Europe.

Fossils of the Palæozoic rocks of the Asturias.

*Orthoceratites Jovellani.**
Cardium (resembling C. alæforme, Sow., and identical with a species from the limestone of Nehou, La Manche).
*Terebratula subconcentrica.**
—— *Pelapayensis.**
—— *Campomanesii.**
*Terebratula Ferronesensis.**
—— *Ezquerra.**
—— *Hispanica.**
—— *Toreno.**
—— reticularis, Schlotth. (T. prisca, Dalm.)
—— *Oliviani.**
—— *Adrieni.**

Terebratula Daleidensis, Röm.
*Spirifer Pellico.**
—— *Cabedanus.**
—— heteroclitus, Defr. (sp.)*
—— *Cabanillas.**
—— Verneuili, var., Murch.
Orthis resupinata, Mart. (sp.)
—— orbicularis, Sow.*
—— crenistria, Phil. (sp.)
Leptæna Murchisoni, D'Arch. et De V.*
Leptæna Dutertii, Murch.
Serpula omphalotes, Goldf.
Pentremites Pailletti, De Vern.*
—— *Schulzii.**
Aulopora serpens, Goldf.
Criserpia Michelini, Miln. Edw.
Favosites polymorpha, Goldf.
—— fibrosa.
—— —— var. ramosa.
Lithodendron cæspitosum, Goldf.

NOTE.—The species in italics are new; and those to which an asterisk is attached are described and figured by the authors in the original memoir above referred to.

The relative preponderance of Brachiopoda is, it is well known, the distinctive character of the Palæozoic faunas, just as the preponderance of Cephalopoda, represented by Belemnites, Ammonites and other of the siphoniferous multilocular genera, marks the secondary period.

Among the Brachiopoda, of which two-thirds of the whole number of our series of Asturian fossils consist, those most remarkable by their peculiar mode of development are the Terebratulæ of the group called *Concentricæ*, characterized by concentric striæ more or less lamellar, by the uniform absence of *deltidium*, and by a round aperture at the beak of the ventral valve. The *T. concentrica*, V. Buch, the type of the group, and a species found in the Devonian beds of northern and western France, of England, Belgium, the Eifel and Russia, does not however appear among these specimens from Spain, although six species, one of which we have named *T. subconcentrica*, from its very close resemblance to this typical form, —a resemblance so near that it might almost be considered as a variety,—form a link connecting it by common characters, although gradually diverging from it more and more widely by successive modifications.

The presence of a medial furrow is the peculiar character which connects these very different forms. This furrow, hardly appreciable in *T. subconcentrica*, which is distinguished from the type of the group by its generally rounded, subelliptical and transverse form, its large dimensions and the disposition of its striæ, is seen to be combined in the next species (*T. Pelapayensis*) with a subpentagonal and more elongated form, smaller dimensions, and a less open angle at the apex. Still more decidedly indicated in *T. Campomanesii*, the medial furrow is there accompanied by folds and lateral furrows, and the front of the ventral valve is little different from that of the dorsal one. The large and lamellar striæ of this species, present at all stages of growth, clearly distinguish it also from *T. Ferronesensis*, where indeed the development of four plications on each valve, separated by broad and deep furrows, the striæ becoming still finer and closer together, would fully justify the separation.

Up to this point the forms had oscillated, if we may use the ex-

pression, between pentagons more or less rounded and ellipses more or less elongated; but at length departing from this character, we find the transverse direction predominate in *T. Ezquerra*, by the extreme elongation of the two lateral folds which we have traced from their first origin in *T. Campomanesii* through their further development in *T. Ferronesensis*. At the same time, the angle at the apex becomes more open, the ventral furrow is as deep as the dorsal one, the general contour of the shell becomes heptagonal, and its surface becomes divided into five parts, which are hollow and unequal, but disposed symmetrically on each side of the axis, and corresponding on the two valves. The *T. Hispanica* is simply the result of a still greater extension, and of an elevation of the lateral folds, which in it become confounded with the hinge, which is straight and very long, as in the winged Spirifers. The angle at the apex is nearly equal to two right angles, and the medial furrow is always as deep as the sinus. Lastly, the variety (A) of *T. Hispanica* presents the concluding term of this series of transformations, which, commencing with a suborbicular shell, has conducted us gradually to a form very nearly resembling that of a *Solen*.

We have paid every attention in determining these species; and the examination of a considerable number of individuals of each of them, in various stages of growth, induces us to think that the distinctions we have established are well founded, and that they will be confirmed by future investigations. Among the species, *T. Pelapayensis* occurs both in the Ural and Eifel Devonian beds, and *T. Ezquerra* in the limestones of Nehou (Manche).

If we inquire concerning the localities already known of the other fossils in the preceding list, we find that *T. Adrieni* occurs in the Eifel limestone, *T. reticularis* is common to the Silurian and Devonian rocks of the north and east of Europe, and *T. Daleidensis* appears in the grauwacke of the banks of the Rhine. Among the Spirifers, one variety of *S. heteroclitus* and a variety also of *S. Verneuili* are confined to Devonian beds; and the three other species, which are as yet peculiar to the Asturias, recall to mind by their transverse form and simple plications the characteristics of the genus, especially as developed during the Devonian period. All the three species of *Orthis* are known: *O. crenistria* is a Devonian form, *O. resupinata* both Devonian and Carboniferous, and *O. orbicularis* Silurian; but with regard to the latter, there is some doubt still as to its identity. Of two species of *Leptæna*, one, *L. Dutertrii*, is common in the Devonian beds of the Bas Boulonnais; and the other, a variety of *L. Murchisoni*, the type of which occurs in the grauwacke of Siegen, is somewhat widely spread in the ancient limestones of Brittany and Normandy.

Among the Polyparia of Ferrones, three are species common to Silurian and Devonian rocks, and two are exclusively Devonian. *Serpula omphalotes* is one of the most characteristic of the Devonian fossils both in Western Europe and in various parts of Russia; and, lastly, the presence of two species of *Pentremites*, a genus hitherto unknown in the Silurian system, furnishes a still further

argument for referring these beds of Ferrones and Pelapaya to the Devonian period.

On the whole, therefore, we find that of thirty-one species obtained from these localities, three, namely *Terebratula Daleidensis, Orthis orbicularis,* and *Leptæna Murchisòni,* are true Silurian, four are Silurian and Devonian, one (*Orthis resupinata*) is Devonian and Carboniferous, eight are exclusively Devonian, and fifteen are new. Of these latter, however, three have been found in the Devonian rocks of other countries, so that as many as eleven, or about one-third of the whole number of species known, are exclusively Devonian.

Besides the fossils of Ferrones, Pelapaya and the neighbourhood, M. Paillette has also sent some specimens from Arnaos, where the beds of true coal, which he has described in his memoir, appear to be covered up by limestones similar to those of Ferrones. Among the species thus obtained, the specimens of which are generally less perfectly preserved than those previously described, we have *Terebratula reticularis* (*prisca*), *T. Ezquerra*, *T. primipilaris* (Von Buch), *Orthis resupinata*, *O. striatula*, *O. arachnoidea*, and the *Spirifer Pellico*, so characteristic of the Ferrones limestones. It is impossible to doubt that these beds of Arnaos are of the same age as the others*.

As to the fossils of Cabrales, for which we are also indebted to M. Paillette, they are quite distinct from the preceding, and certainly announce the presence of the true carboniferous series at this point. They consist of *Productus semireticulatus*, Mart. (*antiquatus*, Sow.), and *P. tenuistriatus*, De Vern., *Spirifer attenuatus* or *striatus*, and *S. Mosquensis*.

D. T. A.

* We think it right to call attention to this fact, since it is the first time that fossils unquestionably Devonian have been found regularly superposed on beds of workable coal. All the great coal and anthracite deposits of England, America and Russia are well known to be superior in geological position to the Devonian system.

MISCELLANEA.

I. *On* Icebergs *in the* Southern Hemisphere, *and the Boulders and Erratic Blocks conveyed by them.*

[In the *Narrative of the United States Exploring Expedition during the years* 1838 *to* 1842, by Charles Wilkes, U.S.N., Commander of the Expedition*, there appear some remarks of great interest to geologists with respect to the icebergs in the southern hemisphere. To the volumes themselves the Editor is not at present able to refer, and he is indebted for the following particulars to an extract given in 'Silliman's Journal' for July last, where the reference to pages is not given.—Ed.]

The ice-islands form rapidly in successive horizontal layers from accumulations of snow assisted by the fogs. These layers are from six inches to four feet in thickness; and the icebergs were seen in all stages of formation, varying from 180 to 210 feet in height, attached to the land, and forming a straight and perpendicular wall in advance of the land, for a distance of fifty miles and more together.

Detached from the land, but found along the coast, the icebergs were from a quarter of a mile to five miles in length. At a distance of about fifty or sixty miles from land they exhibited marks of decay, and the stratification was often inclined at a considerable angle to the horizon.

In the southern seas, these ice-islands float down as far as latitude 60°, without being much changed by melting, since the temperature of the sea shows but little alteration from this point towards the pole. Further towards the equator their texture is altered, and they rarely exhibit signs of stratification. They drift rapidly westwards and north-westwards at an average rate of from half to three-quarters of a mile an hour, and they are frequently found between latitudes 40° and 50° S.

Vast multitudes of boulders are imbedded in these icebergs. All those observed apparently formed part of the nucleus, and were surrounded by extremely compact ice, so that they appear to be connected with that portion of the ice which would be the last to dissolve, and they would therefore in all probability be carried to the furthest extent of their range before they were let loose or deposited.

Captain Wilkes concludes, from the abundance and drift of icebergs, as well as from other causes, that the land near the South Pole is very extensive.

* Five volumes, with atlas. Philadelphia 1845.

II. Upheaval *of a* Chain of Hills *in Modern Times.*

[The following interesting notice is translated from the second volume of M. Tschudi's work on Peru, now in course of publication. It presents an instance of elevation of a kind of which examples appear to be very rare, but an almost parallel case is quoted by Mr. Darwin (Journal, 2nd ed. p. 359), to whom the Editor is indebted for pointing out the passage here translated.]

Two leagues from Lima the road which up to that point has run in a north or north-westerly direction suddenly turns towards the north-east, and follows the course of the river Chillon as far as Cavallero. From this point there is a steep and continued ascent in the same direction (north-east) as far as Llanya, but at a considerable distance from the river, which takes a wide turn to the north. From Cavallero the road proceeds for a distance of about eight miles through a district entirely barren, and along the dried-up bed of a river (thence called Rio seco, dry river). All this time there is a steady ascent, the last half league being tolerably steep, until we reach the crest of a chain of hills which extends directly across the valley. The ground is covered with boulders and blocks of porphyritic rock, just as in the river-bed of the Rimac. As soon as we reach the crest of the hilly chain, there is seen, on the other side, a valley resembling the dried bed of a lake, along whose middle may be traced a furrow—the prolongation of the bed of the stream broken through by the elevation of the hills. After going up this valley and following for nearly three leagues the bed of the 'dry river' as far as the village Alcocoto, we again find ourselves on the banks of the river Chillon.—*Peru, v. J. J. v. Tschudi*, 2 Bd. s. 8.

III. *On* Marine Infusoria *in* Volcanic Tuff.

It has been a matter of considerable interest to those who are pursuing microscopic investigations, that in the various examples of volcanic rock, such as pumice, ash, tufa and other materials, in which infusorial animalcules have been determined, the species thus met with have hitherto all been referable to freshwater groups.

In the case of some examples of volcanic ash procured by Mr. Darwin, and recently examined by Prof. Ehrenberg, several species of marine types have however been met with. The specimens examined were from Patagonia.—*Berlin Academy*, '*Bericht*,' 1845, p. 143.